NASA Magazine

fall 1993

from the administrator

As we move forward with our next issue of *NASA Magazine*, so we are moving forward with NASA's plans for the future.

There is a vision that encompasses the whole range of NASA's activities, some of which you will read about in these pages.

But the center of attention these days *is* the space station and it is indeed critical to the future of America's human space flight program.

We need a laboratory in space for the pursuit of cutting edge science. For the first time in our history, we now have the capability to manipulate gravity as a variable both in scientific research and in our understanding of new manufacturing techniques. Aboard the station, our ability to remove gravity from the equation will become a powerful tool in a wide range of scientific and technological pursuits. As we learn, those new insights will fuel U.S. industries, from biotechnology and biomedical to electronics, communications, robotics, superconductivity and other high-technology applications.

A space laboratory will provide new insights into the inner workings of the human body that could be profound. During long duration space flights, the body changes and adapts in dramatic ways. Studying these changes adds to our knowledge of basic biological processes. One device—the Rotating Wall Vessel—built for use aboard the space station is already producing dividends in the study of various forms of cancer. At locations around the country, medical researchers are studying the formation of tumors, generating new insights into breast and ovarian cancers, among others.

A space station is also the perfect testbed for developing the robust spacefaring technologies of the 21st Century. No longer limited to brief sorties, the United States will be able to capitalize on the expense and risk of leaving the Earth and maximize the four absolutely critical spacefaring resources: time in orbit, available power, room to work and humans to do the work.

On board the space station, we can evolve basic skills and learn how various materials and structures react to the harsh space environment. Solar arrays, wire bundles, coatings, paints, various metals and alloys all react in different ways over different time intervals. A better understanding of the effects of ultraviolet light, for example, could revolutionize paints and coatings used in homes and factories on Earth.

The dynamics of large structures, the payoffs that come from new ways to generate and transmit power, the insights that come from better water recycling techniques—these and many other lessons from space can greatly improve America's technological know-how. That knowledge in turn can make the nation much more competitive in the rigorous marketplace of the 21st Century.

Space exploration can provide the catalyst for a new era of international peace and cooperation. The space station is already the largest international peacetime scientific venture in history. For a decade, we have been working closely with Japan, Canada and ten European nations to develop this international orbital science laboratory. Now that Vice President Al Gore and Russian Prime Minister Chernomyrdin agreed in September to conduct joint studies, we could have a dramatic new program of cooperation in space, aeronautics and science. By pooling the resources of the two most experienced spacefaring nations, the progress of human space flight could be accelerated during the 1990s.

In closing, I believe that space flight can enrich the lives of our children and future generations, and space station is critical to continuing the progress of human space flight. The space program is a powerful expression of the human drive to explore and discover. Space travel is one of the epic developments of the 20th Century, where, within only a few short years of having developed the technology to enter space, humans immediately proceeded to do so. "It's human nature to stretch, to go, to see, to understand," astronaut Michael Collins wrote. "Exploration is not a choice, really, it's an imperative." •

–Daniel S. Goldin

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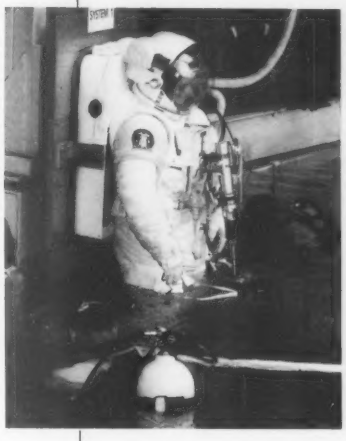

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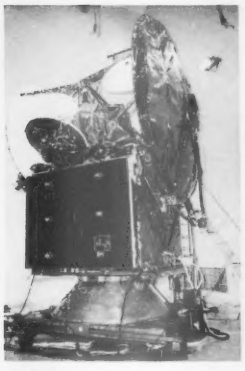

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Contest winners from Zia Middle School, l.to r.: Rebecca Polanco, Claudia Dominguez, Summer Parra, Sarah Conner and teacher, Elaine Hampton.

Name That Terminal

Thanks to a group of New Mexico middle school students, NASA's two Tracking and Data Relay Satellite System (TDRSS) ground stations located near White Sands have new names. The ground stations, which relay data, voice messages and video to and from Space Shuttles and Earth-orbiting satellites, have been renamed "Cacique," which means "leader," and "Danzante," which means "dancer." Both names refer to the Tortugas Indians of New Mexico, who preserved their culture through traditional dance. Rules for the contest stipulated that entries had to relate to Native American, Hispanic or African American local culture; be appropriate for space communications and America's involvement in space; be limited to one or two words, and show a relationship between the two names. The winning entry was submitted by four students from the Zia Middle School in Las Cruces. The contest was sponsored by NASA, the New Mexico Space Grant Consortium and New Mexico State University.

Kids Onboard

Is it silly putty? Is it crazy glue? No, it's...Oobleck, a cornstarch-based material that flew in a special container with the STS-57 Space Shuttle crew in June. Second-graders from the Poquoson Elementary School near the Langley Research Center examined the material after the flight to note any property changes. The investigation was part of Langley's "Can Do" project, whose primary payload, GEOCAM, consisted of four Nikon 35mm cameras that took 1,000 photos in orbit. The photos are being compared with 20-year-old Skylab photos of Earth to see what changes have occurred in that time.

Second-graders Erin Walker, Natalie McBride and Heather Stanley study their "Oobleck."

PHOTO/BILL INGALLS

President Bill Clinton greets astronaut Ellen Ochoa at the Hispanic Heritage Celebration at the Washington Hilton Hotel on September 16. Ochoa received the 1993 Medallion of Excellence Award from the Hispanic Caucus.

NASA's Paris Air Show exhibit welcomed visitors with a photomural acknowledging the Agency's international partners in space.

Paris When It's Haute

Accompanied by the deafening roar of Russian Sukhoi and American F-16 jets flying high overhead, NASA hosted more than 130,000 visitors at its Paris Air Show exhibit in June. In spite of lower overall attendance at the show due to cold, rainy weather, NASA's exhibit was visited by more people than in any recent year, partly due to the popularity of its videowall display. President Clinton's representative to the show, Secretary of Commerce Ron Brown, was escorted through the exhibit by astronaut Pierre Thuot and NASA exhibits manager Jack Schmid. When Brown noticed former astronaut Kathryn Sullivan—now chief scientist for the Commerce Department's National Oceanic and Atmospheric Administration—featured in the videowall, he commented with pride about *his* employee.

A separate aeronautics exhibit focused on NASA's high speed research program, which was of particular interest to the show's many professional and business visitors. The exhibit featured several videos, photos and text describing the program in detail, including models of the Perseus high-altitude research plane, a large High Speed Civil Transport model, a Mixer-Ejector Nozzle test article and a wind tunnel model of the latest innovations in aerodynamic design.

Mars Observer

Timothy Coffey, Director of Research at the Naval Research Laboratory (NRL) in Washington, D.C., was named by NASA Administrator Dan Goldin as the Chairman of the Mars Observer Investigation Board in August. In early September, Coffey selected the remaining board members "based on their significant experience in the development, acquisition and operation of space systems." The board includes: Thomas C. Betterton, rear admiral, United States Navy; Peter G. Wilhelm, director of the Naval Center for Space Technology, NRL; Michael D. Griffin, chief engineer, NASA; Joseph Janni, chief scientist, Air Force Phillips Laboratory, and Kathryn D. Sullivan, chief scientist, National Oceanic and Atmospheric Administration.

The board will investigate and determine, to the extent possible, the cause of the loss of communications with Mars Observer and recommend corrective actions to prevent a recurrence in future missions. The board plans to present its findings to Goldin in late November. A final report will be released and made public after final acceptance by Goldin. Communication with Mars Observer was lost at 6 p.m. PDT on Saturday, August 21. The spacecraft was set to enter Mars orbit at approximately 1:30 p.m. PDT on Tuesday, August 24.

A Bright Idea

Since the beginning of the Space Age, solar arrays have been a reliable source of electric power for satellites. But what about when the Sun isn't shining? How do you get power to stations on the night side of the Moon, or to satellites when they pass through the shadow of the Earth? One answer is to beam light to the solar arrays using a laser.

The idea of using powerful Earth-based lasers to send power to a Moon base during the long lunar night or to satellites in geosynchronous orbit was first proposed by Geoffrey Landis at the Lewis Research Center. Around that same time, John Rather at NASA Headquarters started independently to champion a laser-powered lunar base. The new technology of

PHOTO/JACK SCHMID

The Glasair III LP (lightning protected) kit-built airplane on display outside the NASA exhibit at the Oshkosh air show in August.

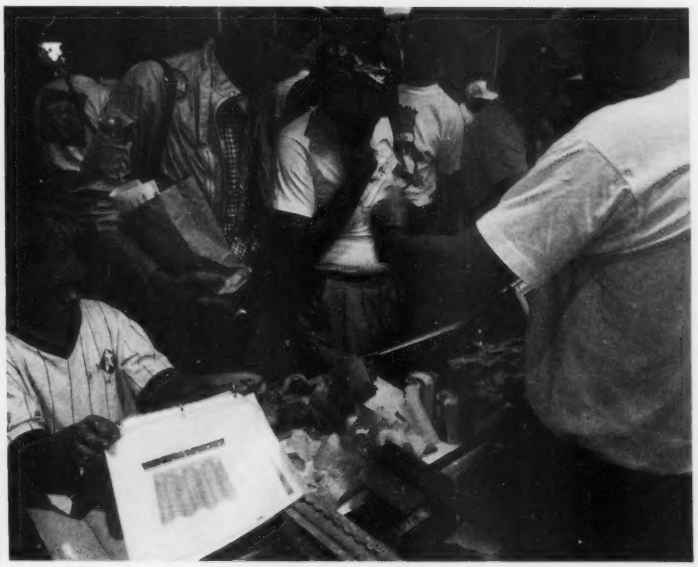
adaptive optics, originally developed for military applications, makes it possible for laser beams to pass through the atmosphere with very little distortion. A beam transmitted from Earth to the Moon would illuminate a spot only 80 meters across—smaller than a football field.

To develop this technology, a unique collaboration has begun involving several NASA centers. Scientists at the Marshall Space Flight Center are developing the overall system design and adaptive optics, while engineers at the Jet Propulsion Laboratory are working on a "beam director" to launch the laser beam into space. Scientists at Lewis, meanwhile, are designing photovoltaic receivers to turn the laser power into electrical power in space. A demonstration of power transmission to a satellite in orbit is currently planned for sometime in 1998.

Flying High at Oshkosh

This summer's 41st annual Experimental Aircraft Association Fly-In and Convention, better known as the Oshkosh Air Show, once again counted NASA as one of its exhibitors. Oshkosh, with its enthusiastic aviation supporters from every state in the Union and more than 75 foreign countries, is one of the premiere events in the world of aeronautics.

Fifteen thousand people flew their own airplanes to Oshkosh in August, making Wittman Field the busiest airport in the country—at least for one week. Fortunately, 50 air traffic controllers from the Federal Aviation Administration volunteered to work the tower at Wittman, directing all flyers to safe takeoffs and landings. At least 75,000



The NASA Craftsmanship exhibit was a big hit again this summer at Oshkosh.

Langley engineer Joe Zalameda talks to visitors at the NASA Craftsmanship display at Oshkosh.

more people came in campers, not to mention the thousands of cars arriving every day throughout the show. It was expected that this summer's number of visitors would equal or exceed last summer's 830,000.

NASA's exhibit this year took on a new look, with a particular focus on general aviation. Outside the NASA pavilion, the Glasair III LP (meaning "lightning-protected") was on display —the first lightning-protected "kit-built" general aviation aircraft made of composite materials. This special version of the aircraft was built under NASA's Small Business Innovation Research (SBIR) program, which encourages small companies to participate in innovative, federally supported research projects.

While the Glasair's composite materials and digital electronics offer higher strength, lighter weight and greater efficiency, they also tend to make the aircraft more susceptible to lightning damage. Using results from NASA's Storm Hazards Research Program, the Langley Research Center encouraged Lightning Technologies and Stoddard-Hamilton Aircraft, Inc., to team up and tackle the issue of lightning protection for kit-built aircraft. The plane that resulted from this NASA-industry collaboration was a big success at Oshkosh.

Inside the pavilion, various aeronautics themes were evident throughout. "High Speed for World Travelers," featuring a detailed 10-foot model of a future High Speed Civil Transport, depicted through colorful graphics and photos what NASA is doing to make a next-generation supersonic airliner possible.

"Toward Safer Skies" described NASA's role in making air travel safer for millions of passengers through its research on weather-related hazards such as windshear and icing. "New and Better Aircraft" showcased the Agency's efforts to revitalize and improve subsonic aircraft and the country's airspace system. And NASA's work on leading edge technologies was featured in "New Worlds of Flight," a look at aircraft and aviation systems of the future.

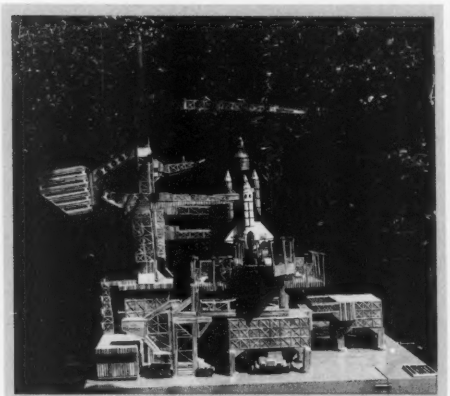
As always, the NASA Craftsmanship exhibit—expanded this year by popular demand—was a big hit with kids and adults alike. Skilled technicians from various NASA research centers discussed and demonstrated how they make wind tunnel models and test instruments related to NASA's advanced aeronautics research. In addition, the Marshall Space Flight Center supplied outstanding exhibits on the Space Station, technology utilization, space science and the upcoming Hubble Space Telescope servicing mission.

Visitors at the NASA exhibit at Oshkosh.

Gary Schiffmann of St. Germain, Wisconsin, built this shuttle for his grandchildren and brought it to the air show.

STS-63 Coming Up

Astronaut James D. Wetherbee will command the STS-63 mission aboard Discovery in mid-1994. Other crew members are Eileen M. Collins as pilot, and mission specialists C. Michael Foale, Janice E. Voss, Bernard A. Harris, Jr., and Russian cosmonaut Vladimir G. Titov. The STS-63 mission will include the third flight of Spacehab, the deployment and retrieval of the Spartan-201, and a first-ever rendezvous with the Russian space station Mir. This will be Wetherbee's third Shuttle flight; he flew as commander on STS-52 and pilot on STS-32. Collins is the first female to pilot a Shuttle mission. Foale was a mission specialist on STS-45, and on STS-56 last April. Voss was a mission specialist on STS-57 in June, and Harris flew as a mission specialist on the STS-55 Spacelab D-2 mission. Titov commanded Soyuz T-8 in April 1983 and in December 1987, Soyuz TM-4, which docked with the orbiting Mir 1 space station. Titov spent 365 days, 22 hours and 39 minutes in space, setting a long-duration world record. He also performed two spacewalks during his mission. •



Francisco Javier Lopez Castillo, a young artist from the Dominican Republic, sent this photograph of a model he built to the United States Embassy in Santo Domingo, which forwarded it to NASA Headquarters. His model, which took him a year to finish, is made of materials from around the farm where he lives, such as leaves and stems from corn, fibers and leaves of the plantain tree, and wood.

TRANSITION

Retiring

Johnson Space Center director **Aaron Cohen** retired from NASA on August 20. Friends and colleagues gathered at Space Center Houston on August 27 to honor him for his profound contributions to America's human space program. Cohen will become the Zachry Professor of Engineering at his alma mater, Texas A&M University.

Richard H. Kohrs, director of the space station office in Washington, retired from NASA in September after 30 years of service to the agency in Houston and in Washington. Kohrs was appointed space station director in June 1989 with the responsibility for the design, development and future operations of the space station. He began his career with NASA in 1963 at the Johnson Space Center, then known as the Manned Spacecraft Center.

Honored

NASA astronaut **C. Michael Foale** received the Air League of Great Britain Founders Medal on June 8 from HRH Prince Philip, Duke of Edinburgh, one of the patrons of the League. The presentation ceremony took place during Foale's STS-56 post-mission hometown visit to Cambridge and London. Although born in Louth, England, Foale considers Cambridge his hometown. Before flying as a mission specialist on the STS-56 Discovery mission last April, Foale flew on the STS-45 mission in March 1992.

Astronaut Michael Foale receives a medal from Prince Philip.

Aaron Cohen, retired Director of the Johnson Space Center, and **Robert J. Schwinghamer,** Deputy Director for Space Transportation Systems at the Marshall Space Flight Center, were two of 31 federal employees recognized in May as the top engineers for their agencies by the Professional Engineers in Government division of the National Society

of Professional Engineers.

In June, **Jer-Nan Juang** of the Langley Research Center was selected by the American Institute of Aeronautics and Astronautics as the 1993 recipient of the AIAA Mechanics and Control of Flight Award. The award is presented for an outstanding recent technical or scientific contribution by an individual in mechanics, guidance, or control of flight in space or the atmosphere.

Roland Bowles, Rosa Oseguera, and **Paul A. Robinson,** engineers in Langley's Flight Systems Directorate, have been recognized by *Research and Development* magazine for coming up with a technique for in situ (at the airplane's location) measurement of wind shear using conventional aircraft sensors. This improved method received an R&D 100 award for one of the 100 most significant new technical products of 1993. The award is presented annually and is selected by a panel of scientists and engineers after studying new technology from around the world.

Changing Jobs

Astronauts **Guion S. Bluford, Jr.** and **Mark N. Brown** left NASA in July to pursue other interests. Bluford, who

Guion S. Bluford

Mark N. Brown

retired at the same time from the Air Force, joined NYMA Inc., a Greenbelt, Md., firm as vice president and general manager of the Engineering Services Division. Bluford was among the first group of Shuttle-era astronauts selected in 1978. He was the first African-American astronaut to fly onboard the Shuttle (on STS-8 in August 1983) and has since been a mission specialist on three other Space Shuttle flights.

Brown also is retiring from the Air Force as he leaves NASA. He will head the Space Division office of the General Research Corporation in Dayton, Ohio. Brown served as a mission specialist on two Space Shuttle missions, STS-28 in August 1989 and STS-48 in September 1991.

Astronaut **James P. Bagian** is taking a leave of absence from NASA to work as vice-president of corporate development and medical affairs at Somanetics Corporation in Troy, Mich. Bagian will use his medical and engineering expertise to head the company's clinical research activities. Selected as an astronaut in July 1980, he was a mission specialist on Shuttle flights STS-29 in 1989 and STS-40 in June 1991. He will return to flight status upon his return to NASA.

France Anne Cordova, head of the Astronomy and Astrophysics Department, Pennsylvania State University, will assume the responsibilities of NASA chief scientist in January. She will be on extended detail from the University to NASA. In this position, Cordova will be administrator Daniel Goldin's senior scientific advisor and the principal interface between the administrator and the national and international science community. One of her critical duties will be to coordinate an integrated strategic plan for all the scientific disciplines across NASA. Cordova presently serves on the President's National Medal of Science Committee and is a member of the Space Science and Applications Advisory Committee of the NASA Advisory Council. She has served on the Roentgen X-ray Observatory International Users Committee; the Extreme Ultraviolet Explorer Guest Observer Working Group; and the Hubble Space Telescope Advanced Camera Team.

Died

One of the original seven astronauts selected by NASA in 1959 for the Mercury Program (see page 28) died in June. **Donald K. "Deke" Slayton,** 69, died of complications from a brain tumor.

Deke Slayton

NASA Administrator Dan Goldin said, "The entire NASA family has been saddened to learn of the passing of Deke Slayton. As one of the original seven Project Mercury astronauts, he will be remembered as a true pioneer of the Space Age. Deke was an 'American original,' a true national hero, and we will miss him."

Slayton flew as Apollo docking module pilot for the Apollo-Soyuz Test Project in 1975, a joint U.S.-Soviet flight that featured the first, and so far only, meeting in space of astronauts and cosmonauts. •

Last summer's votes on the Space Station were the closest yet, and they tell us something about voting trends among the newest members of Congress.

Close Calls

by Dr. John Lawrence,
Office of Legislative Affairs,
NASA Hq.

There are two lessons you must learn if you want people to think you're a Washington insider. Lesson One has to do with the analysis of recent significant Congressional action. Lesson Two involves the prediction of future Congressional action.

In Lesson One, you'll learn to explain why the House voted twice in less than a week last summer on whether to kill the Space Station; why some members changed their votes in a span of five days; why we fared better on the appropriations vote than on authorization; and finally, what happened to that comfortable margin of support we had for the Space Station in past years?

The budget, you'll remember, evolves along two paths— authorization and appropriations. As it happened this year, the House took up NASA's authorization bill on Wednesday, June 23, and the appropriations bill came to the floor on the following Monday. Amendments to terminate the Space Station accompanied both measures. The Station barely survived the authorization vote, 216 to 215. The vote was particularly ominous, since past votes to terminate the program had been more favorable to NASA on the authorization bill. With the appropriations vote just days away and the anticipation of losing votes, the outlook was grim.

Some observers have described the 216-215 vote as a "wake-up call." Space Station supporters in the administration, the scientific community, the aerospace industry, and in Congress worked in earnest over the next several days, promoting an awareness of the merits of the program. That may well be what accounted for the swing that resulted in a 220-196 victory for the Station in Monday's appropriations vote.

It may also have been in NASA's favor that the vote was held on a Monday. Members of Congress typically return to their districts on weekends, and depending on airline schedules, some may have difficulty returning for Monday sessions. In this case, 24 members did not vote on the NASA appropriation, and voting records suggest that 15 of them would likely have opposed the Station.

The wider margin of the appropriations victory was a departure from the past. The fiscal year 1993 cycle was more typical, when the Station survived by 254-159 on the authorization bill, and by 237-181 on appropriations. Most members who switch regard the authorization as a "free" vote. It gives them the opportunity to express support of the program on an ideological level, without committing money. In the appropriations cycle, programs must be considered in the context of competing financial needs.

In comparing the fiscal year 1993 and 1994 votes cited above, we see a substantial loss of support for the Space Station. The House's 116 freshmen members account for a large part of that shift. Sixty-five freshmen voted to terminate the Space Station authorization.

As a Lesson One bonus, here's an interesting aspect of the freshmen class that is beginning to emerge from the voting records. In a previous column we spoke of party unity votes, defined as those in which the majority of members of one party vote against the majority of the other party. Unity has steadily increased since the 1960s, when scores were in the mid-60 percent range, to the 1990s, when the scores have climbed to the mid-80 percent range. The trend continues. Thus far in the current Congress, first-term Democrats in the House have supported their party in 93 percent of all votes (compared to the 90 percent average for all House Democrats), and Republican freshmen have scored 90 percent (compared to an 88 percent Republican average).

Now, as for Lesson Two on predicting future Congressional action: Don't even think about trying it. •

With a Headquarters job that keeps her indoors most of the time, Danalee Green goes running every chance she gets. And not just around the block, either. This year she and her teammates placed first in their age group in the Boston Marathon.

Just For the Run of It

by Sonja Alexander

What started 16 years ago as a challenge from her NASA co-workers to run an agency-sponsored two-mile race has turned into a lifetime habit for Danalee Green.

"I had to run and walk that first two miles," she recalls, "but it was the start of a lifetime commitment to good health and fitness."

Green, chief of the Management Controls Office in the Headquarters Office of Management Systems and Facilities, became such an avid runner, in fact, that by 1983 she decided to try out for the Boston Marathon. In order to qualify, she first had to run another marathon within a specified time. Unfortunately, she didn't make it.

But last spring, at the age of 46, Green decided to take another shot at the Mother of all Marathons. Once again she planned to qualify by first running the Marine Corps Marathon in Washington, D.C. This time she had a new attitude and a new training regime, not to mention 10 more years of experience and determination. Last October, having followed a very rigid training schedule of daily workouts for three months beforehand, Green joined more than 12,000 other runners in the Marine Corps Marathon. Her time of 3 hours and 22 minutes not only qualified her for Boston, but also set a new personal record, which was 10 minutes faster than her time had been at the age of 36.

Green's explanation is simple: "We don't get older, we get better."

The Annapolis, Maryland, resident feels that her attitude about training was more mature and disciplined this time around. And it paid off: Last April she ran the Boston Marathon—all 26.2 miles of it—in 3 hours and 36 minutes, good enough to place her in the top 20 percent of all women who ran the race.

Green says that running Boston in a reputable time fulfilled one of her life goals.

"Imagine that," she says, "the number of miles I drive to work every day, I ran on foot in less than four hours."

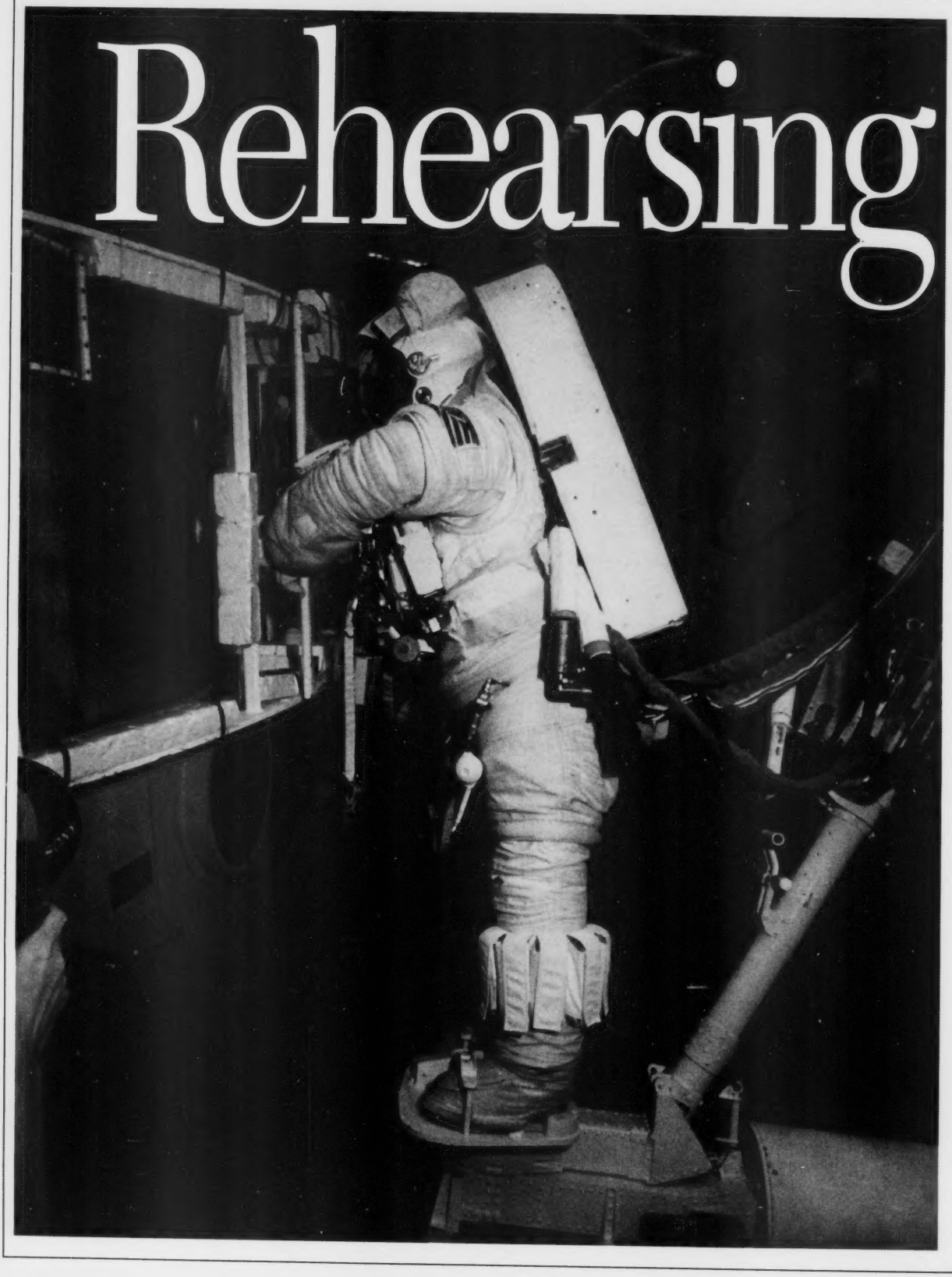
Green belongs to the "Annapolis Striders" running club, which fielded a three-woman master's team, (all over the age of 40) to "do Boston" this year. Green was one of the three. Out of 10 women's master's teams, hers came in first—a full nine minutes ahead of the second-place team.

Running isn't the only arena in which Green, a NASA employee for 22 years, has proven herself. Last year her staff nominated her for a Creative Management Award for developing a technique to review and improve control processes throughout the agency. She received the award last fall.

Green believes that running helps to relieve the tension and stress that comes with her daily work routine. Far from being a distraction, she says it has sharpened her performance on the job.

"Some of my best solutions to problems," she says, "have come to me during my run." •

Rehearsing



for the Show

By Lori Keesey and Trish Pengra

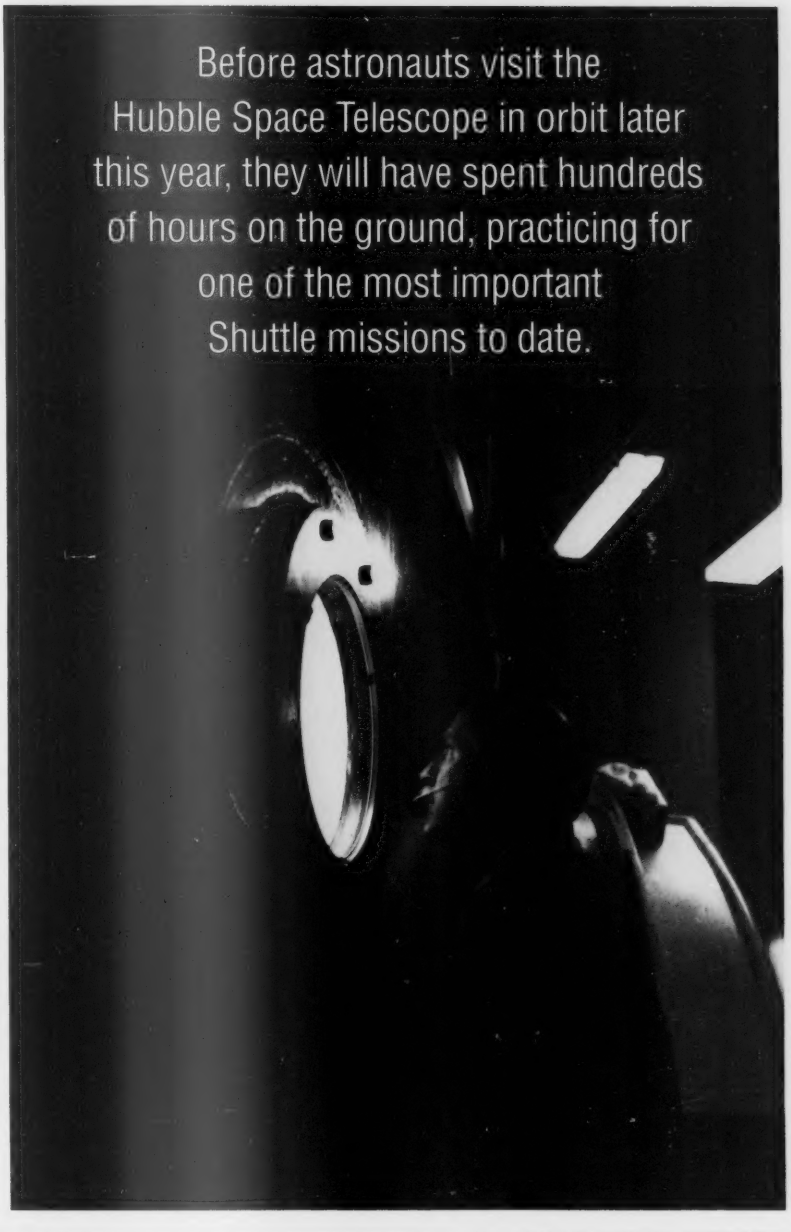
Story Musgrave leans back in his chair, casually watching the underwater dance that unfolds before him on a dozen TV monitors in Marshall Space Flight Center's mission control room.

Inside a giant water tank housed in a hangar not far from where Musgrave sits, Kathryn Thornton, wearing a bulky, 180 kilogram spacesuit, snaps the last of six j-hooks on the bay door of a spacecraft immersed in the tank. Meanwhile, her similarly clad underwater partner, Tom Akers, begins stowing the last of the tools.

"How do we look, Story?" Thornton asks over the intercom. But Payload Commander Musgrave, the choreographer of this particular performance, doesn't have a chance to answer.

"Like Fred Astaire and Ginger Rogers," Akers quips.

This is just a dress rehearsal. The real show—perhaps the most challenging servicing mission NASA has ever attempted— won't premiere until later in the year, when a crew of seven astronauts flying onboard Space Shuttle Endeavour plans to retrieve the bus-sized Hubble Space Telescope and repair


Before astronauts visit the Hubble Space Telescope in orbit later this year, they will have spent hundreds of hours on the ground, practicing for one of the most important Shuttle missions to date.

At left, astronaut Kathryn Thornton rehearses for STS-61 in Johnson's Weightless Environment Training Facility; right, mission commander Richard Covey observes tank runs at Marshall.

Crewmembers preparing for the Hubble mission are using Virtual Reality as a training tool.

Story Musgrave practices for the Hubble repair mission using the Power Ratchet Tool.

it in orbit.

This practice run, one of many played out over the past several months in NASA's deep water tanks at Marshall and the Johnson Space Center, is designed to find out whether mission planners have allotted enough time for each servicing task. During these runs, the four spacewalking astronauts—Akers, Thornton, Musgrave and Jeffrey Hoffman, with assistance from Claude Nicollier, who operates the Shuttle robot arm—work inside "neutral buoyancy" tanks that simulate the weightlessness of space.

By the time Endeavour blasts off, the four astronauts will have logged nearly 400 hours underwater, plus hundreds of hours at other training facilities, fine-tuning their

skills in preparation for the mission. And that doesn't include the training time racked up by mission Commander Richard Covey and Pilot Kenneth Bowersox, who are responsible for flying Endeavour and making sure the rendezvous and grappling of Hubble go as scheduled.

Never before has a Shuttle crew spent so much time training for their spacewalks. Never before have Shuttle astronauts used such an array of different training techniques, some of them resurrected from the early days of the U.S. space program. And never before have they carried so many mission-specific tools in space.

Why has NASA adopted these unprecedented measures? What makes STS-61 so special?

For one, the flight includes five scheduled spacewalks, with the possibility of adding two more should astronauts need the additional time. The number of planned spacewalks is unprecedented for a Shuttle mission. Second, this will be NASA's first repair of a completely serviceable satellite designed for on-orbit replacement of parts and instruments. STS-61 will validate whether that idea was a good one.

Others see the mission from a more philosophical point of view, as a way to restore one of the great scientific tools of our century to full health.

"The Hubble Space Telescope is a magical instrument that all people can identify with," Musgrave says. "Possibly it will help them understand their place in the universe."

Many of the NASA civil servants and contractors around the country who serve on the mission team agree that Hubble is not simply a spacecraft.

"We are humbled dealing with this national resource," says Jim Thornton (no relation to Kathryn Thornton), a 33-year-old lead trainer for extravehicular activity, or EVA—

STS-61 payload commander and "choreographer," Story Musgrave.

Tom Akers is lowered into the Marshall water tank.

NASA-speak for spacewalking. "It's very important to do the job correctly and safely."

The telescope, originally conceived in the 1940s by astronomer Lyman Spitzer, was thought to be the most perfect observatory ever built when astronauts deployed it from Space Shuttle Discovery in April 1990. In addition to its perfectly polished primary mirror, the telescope carried five scientific instruments designed to help scientists answer some of the most perplexing astronomical questions known to humankind. With Hubble, scientists hoped to peer far enough back in time and distance to observe the actual birth of galaxies. But all didn't go as planned.

A few weeks after launch, NASA discovered that the telescope suffered from a built-in aberration. Although the telescope had no trouble observing relatively close or bright objects, it didn't live up to original expectations. The blurred vision, caused by an incorrectly shaped primary mirror, prevented scientists from observing objects that were either very distant or were crowded close together.

NASA didn't stand still. While scientists devised computer techniques to clean up the flawed Hubble images, optical engineers diagnosed the telescope's myopia. Two teams worked independently, one examining a faulty device used to measure the mirror's curvature during its construction and the other examining Hubble images to extrapolate what kind of mirror would have produced them. Both diagnoses came to the same conclusion, and engineers came up with a prescription for fixing Hubble's vision.

But how to fit a four-story telescope with contact lenses?

Jim Crocker, an engineer at the Space Telescope Science Institute in Baltimore, devised an ingenious solution—remove one of the telescope's current instruments and install a box containing a mechanical arm equipped with corrective mirrors between the primary mirror and the instruments. COSTAR, the Corrective Optics Space Telescope Axial Replacement, would fix three of Hubble's five instruments while

eliminating one. But because of the way the telescope was configured, it wouldn't correct the vision of the Wide Field/Planetary Camera.

Before this camera had snapped its first picture in space, designers at the Jet Propulsion Laboratory knew it would become the telescope's workhorse. So in the mid-1980s they began building an even better replacement to be installed on the first servicing mission. When NASA discovered the vision problem, JPL engineers carefully modified the design by fitting a set of coin-sized corrective mirrors in the instrument's optics.

In addition to the well-publicized optical problems, telescope operators have encountered unexpected difficulties with the solar arrays provided by the European Space Agency (ESA), which cause the telescope to jitter each time it moves in and out of sunlight every 45 minutes. During STS-61, astronauts will install a redesigned pair of arrays, also built by ESA.

Aside from these problems, NASA officials believe the telescope is operating well. Engineers built redundancy into the system, making sure it had plenty of backup capabilities in the event of problems. So far, few of these systems have been needed. Of the six onboard gyroscopes, three have failed, so to ensure that the telescope continues to operate over its planned 15-year lifetime, astronauts will be installing replacement gyroscopes needed to point the telescope, a magnetometer, which indicates direction much like a compass, and if time allows, other hardware.

Some 10 years before Hubble was launched, engineer Ron Sheffield of Lockheed Missiles & Space Co. had already envisioned the tasks that Akers and Thornton have been practicing in the water tank. He was part of the team that originally designed and built the Hubble specifically to be serviced in space—complete with 67 meters of handrails, 31 places for foot restraints and 92 components that can be easily replaced.

"The thought that's gone into designing these tasks from the very beginning has made them very EVA-friendly," says Jim Thornton, a biomedical engineer at Johnson.

Astronaut Jeff Hoffman: "It's like studying for an exam. You study really hard and are relieved when the exam seems easy. But there's a satisfaction when the questions are hard, and you're really well-prepared."

Despite the fact that the Hubble repair mission involves the most ambitious servicing plan ever attempted, Thornton says the crew will be well prepared. His colleague, Sue Boyd, a lead EVA flight controller at Johnson, is fully aware of the risks involved with a high-profile mission like this one, but she, too, is extremely confident.

"We couldn't be doing anymore than we are already doing," Boyd says—an attitude that prevails across NASA, especially among those involved in planning this flight.

In many ways they're right. For the May 1992 Intelsat mission, during which astronauts snared a wayward communications satellite and boosted it to its proper orbit, spacewalkers trained underwater for 238 hours. The Hubble rescue crew will spend nearly twice as much time practicing.

Learning from past experiences like the Intelsat mission, NASA has upgraded some simulators so that astronauts can rehearse under more realistic conditions. Marshall replaced its tank's single-jointed robot arm with a multi-jointed arm similar to the Shuttle's, and upgraded the astronaut's breathing system to stretch underwater practice sessions from 2 1/2 to 6 hours— about the length of a typical spacewalk.

Although the deep water tanks at Johnson and Marshall simulate weightlessness, they don't perfectly mimic all the conditions in space.

"In the water it's hard to start something moving, but easy to stop it. The exact opposite is true in space," says Hoffman, who is teamed with Musgrave to work 6–1/2 shifts on alternating days.

So NASA has combined different training techniques for this mission—another first. Because the spacewalking astronauts will have to handle the telescope's replacement parts with absolute care, Johnson engineer Richard Fullerton resurrected an Apollo-era training device called Pogo, which operates much like the toy it's named for. When used on a precision air-bearing floor, it helps astronauts learn how much force is required to move large objects in space.

Taking advantage of an emerging technology, astronauts also have used virtual reality as a training tool—another mission first. By wearing special helmets and gloves, the astronauts can "see" and "touch" a three-dimensional computer-simulated model of the Hubble

Jeffrey Hoffman, one of four STS-61 crewmembers who will conduct five scheduled spacewalks during the mission, wears virtual reality helmet and gloves while training for the mission.

telescope secured in the Shuttle's cargo bay.

To get a more realistic sense of what it will be like handling the tools and instruments in space, the Houston-based astronauts traveled to the Goddard Space Flight Center, NASA's lead center for the Hubble telescope, to practice on the High Fidelity Mechanical Simulator, a mock-up that allows astronauts to see how flight hardware fits into the telescope.

The training has been extensive, and to the degree practicable, realistic. At Johnson's Manned Thermal Vacuum Facility, which duplicates the vacuum and temperature of space, astronauts tested each of the more than 100 Hubble-specific tools.

The training was critical. As Hoffman explains, the observatory will be positioned away from the Sun to avoid damage to its sensitive instruments. In the "shade," temperatures plummet to well below zero degrees Fahrenheit.

"On my first EVA, my hands got really cold," Hoffman says, recalling his first flight in 1985 when he made a contingency spacewalk to repair a malfunctioning communications satellite.

Although NASA has seemingly covered all the contingencies, no one expects the mission to go as planned.

"We expect to be surprised," Hoffman says. "It's like studying for an exam. You study really hard and are relieved when the exam seems easy. But there's a satisfaction when the questions are hard, and you're really well-prepared.

"There hasn't been one single satellite yet that hasn't surprised us in some way," he adds.

The test run at Marshall seems to bear out Hoffman's assertions. Well ahead of schedule, Kathy Thornton, perched on the hand of the Shuttle robot arm, finishes one task and is preparing to begin the next. From the television monitors in the control room, Musgrave, Jim Thornton and Boyd watch her open a door. All seems to be proceeding as scheduled until Sheffield walks over to the console and asks Musgrave to tell Thornton to stop. The telescope had not been rotated to the proper position, and she has just opened the wrong door.

"Shoot, I just wasted a bunch of time," she says from inside the tank. Fortunately, this is a practice run; another is planned for the afternoon. In the fall, the astronauts will participate in a full dress rehearsal to practice their parts for the big event. As mission Commander Covey watches the action from a porthole outside the tank, he reflects on what this crew will attempt in a few short months.

"This is the most important mission NASA has ever flown," he says, "and I've got the best seat in the house." •

Lori Keesey and Trish Pengra work for BDM Federal. This is their first article for NASA Magazine.

The Best is Yet to Come

Growing up in the 1950s, astronaut Jeff Hoffman loved reading science fiction. A decade later, a teen-aged Ed Weiler became enamored with space, avidly following the Mercury, Gemini and Pioneer missions.

Although the early space exploits inspired both to become astrophysicists, they followed different paths: Hoffman became an astronaut and Weiler became the program scientist for the Hubble Space Telescope. Now the need to repair Hubble has brought these two men together. Both see the servicing mission as a vitally important effort to improve on an instrument that already has been of tremendous scientific value.

"Hubble has been a discovery machine even with [its] aberration," Weiler says. "The best is yet to come."

Though the world will watch as astronauts outfit the Hubble with special optics, the first corrected images won't be available until several weeks after the Shuttle returns. It will take that long to adjust the coin-sized optics painstakingly to get the best possible focus.

Even without the corrective optics, Hubble has made some amazing observations, say Hoffman and Weiler.

"People are fascinated with black holes, and Hubble seems to have found one," Hoffman says, referring to Hubble's image of galaxy NGC 4261, which looks just like an artist's drawing of the disk of material falling into a black hole. Another Hubble picture of the galaxy M87 seems to bear out the suspicion that some galaxies harbor black holes deep within their cores. The steadily increasing brightness of the galaxy's center suggests that matter is being pulled into the region by an incredibly powerful gravitational force.

Hubble's cameras have given astronomers a better look at Pluto and its moon, Charon, and have tracked an enormous storm in Saturn's turbulent atmosphere. Hoffman is particularly excited by Hubble's image of disks of gas and dust that could someday form planets in the nearby Orion nebula, some 1,500 light-years from Earth. He sees it as "a forerunner of what's likely to be most interesting to the general public over the next few decades—the search for other planetary systems that can support life."

Has the Hubble program been a success, despite the telescope's vision problems?

"The success of the Hubble mission will not be measured by the number of Hubble papers published in scientific journals," Weiler contends. "The real measure will be the mission's long-term effect on the youth of our nation. Will the excitement of Hubble discoveries have the same effect on today's generation as the early days of space exploration had on mine?"—*Trish Pengra*

Hubble's Greatest Hits

Despite its flawed mirror, the Hubble Space Telescope has produced a wealth of scientific information in its more than three years in orbit. Among its most celebrated discoveries:

The Case of the Disappearing Galaxies

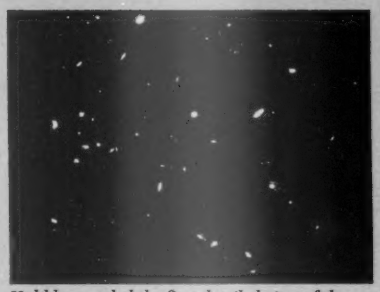
In December 1992 Hubble gave astronomers their first detailed view of the shapes of 300 ancient galaxies located in a cluster five billion light-years away. The observations revealed that early in the Universe, when the light from these galaxies originated, galaxy clusters contained several times as many spiral galaxies proportionally as we see in nearby clusters today. These spiral galaxies have since disappeared through a variety of processes, including mergers with other galaxies and disruption. Before the Hubble observations, galaxies in such remote clusters appeared as nothing more than tiny smudges of light, so there was no way of determining their shape.

A Fuel Tank for a Cosmic Engine

In November 1992 Hubble gave astronomers their best look yet at the workings of a black hole "engine" in the core of the giant elliptical galaxy NGC 4261, located 45 million light-years away in the spring constellation, Virgo. Hubble can't see the hole directly, but it found a Frisbee-shaped disk of dust, 300 light-years in diameter, which is tilted enough to give observers a clear view of the bright hub that presumably harbors a massive black hole. This disk feeds dust and gas into the black hole, where intense gravity compresses and heats the material to tens of millions of degrees. Some gas squirts out from the black hole's vicinity, like twin streams of water from a lawn sprinkler. The spinning disk aligns these gas jets like an axle through a wheel. Before Hubble, the centers of galaxies yielded few of their secrets because the stars there are densely packed together.

"X" Marks the Spot

A June 1992 observation uncovered a striking, dark "X" silhouetted across the nucleus of the majestic Whirlpool Galaxy located in the constellation Ursa Major. The "X" marks the exact position of a suspected black hole that may have a mass equivalent to one million stars like the Sun. The darkest bar might be an edge-on dust ring 100 light-years in diameter, and the diagonal bar of the "X" could be a second ring. The edge-on ring hides the black hole and its accretion disk from being viewed directly from Earth.



Hubble revealed the first detailed view of the shapes of 300 ancient galaxies in December 1992.

When Galaxies Collide

Hubble is providing surprising glimpses of what happens when galaxies smash into each other. These head-on collisions can trigger the birth of new stars, and unexpected new structures can be created in the crucible of destruction. Astronomers were surprised in May of this year to find a rotating, pinwheel-shaped disk of gas at the core of a cosmic train wreck where two disk galaxies had collided. The whirling disk of gas and stars resembles a spiral galaxy, though it is only one-twentieth the size of a typical galaxy. The disk rotates in a direction opposite to the rest of the galaxy, a clear indication that the material originated from the collision. The host galaxy is NGC 7252, located 300 million light-years away in the constellation Aquarius.

A Jurassic Park in Space

Hubble found the astronomical equivalent of live dinosaurs —young globular star clusters—in June 1992. The discovery was surprising because globular clusters are among the most ancient objects in the Universe—estimated to be about 15 billion years old. Hubble uncovered fifty young globulars in the core of a peculiar galaxy called NGC 1275, located 200 million light-years away in the constellation Perseus. Astronomers know the clusters are young because they contain mostly hot bluish stars that are only a few hundred million years old, a fraction of the age of our Sun. Because the clusters in NGC 1275 all seem to be the same age, they must have been created following some cataclysm, such as a collision with another galaxy.

A Cannibalistic Neighbor

The expression "big fish eat little fish" seems to hold for galaxies as well. Peering into the core of the neighboring Andromeda (M31) galaxy in July 1993, Hubble revealed a double nucleus consisting of two star clusters only six light-years apart. One interpretation is that the brighter member of the pair might be the remnant of a smaller galaxy cannibalized by Andromeda. However, Andromeda shows no other evidence of a past cosmic collision. One explanation is that the companion galaxy was small enough to crash into the core of the galaxy without gravitationally disrupting the rest of M31.

Close Encounters of the Stellar Kind

In June 1993 Hubble found a completely new population of very blue stars that have been stripped of much of their gaseous shells. The stars are concentrated in the core of the globular cluster M15, located 30,000 light-years away in the constellation Pegasus. They are among the hottest objects in the cluster, with temperatures reaching 50,000 degrees Fahrenheit—five times hotter than the surface of our Sun. The most likely explanation is that these were once ordinary red giant stars that passed very close to the other stars crowded in M15's nucleus. Such a stellar close encounter would tear away the giant's gaseous shell to expose the extremely hot nuclear fusion "engine" at the star's core.

Embryonic Solar Systems

Hubble's detailed images of newly forming stars confirm more than a century of speculation, conjecture and theory about how a Solar System begins. Hubble hasn't seen planets, but has found broad pancake-shaped disks of dust around 15 newborn stars in the Orion Nebula, a nearby star-forming region. Hubble's November 1992 pictures showed that dust surrounding the stars spreads out into a disk. According to current theories, the dust contained within these disks will eventually agglomerate to make planets. Our Solar System is a relic of just such a dust disk that accompanied our Sun at its birth 4.5 billion years ago.

—Ray Villard, Space Telescope Science Institute

Opening

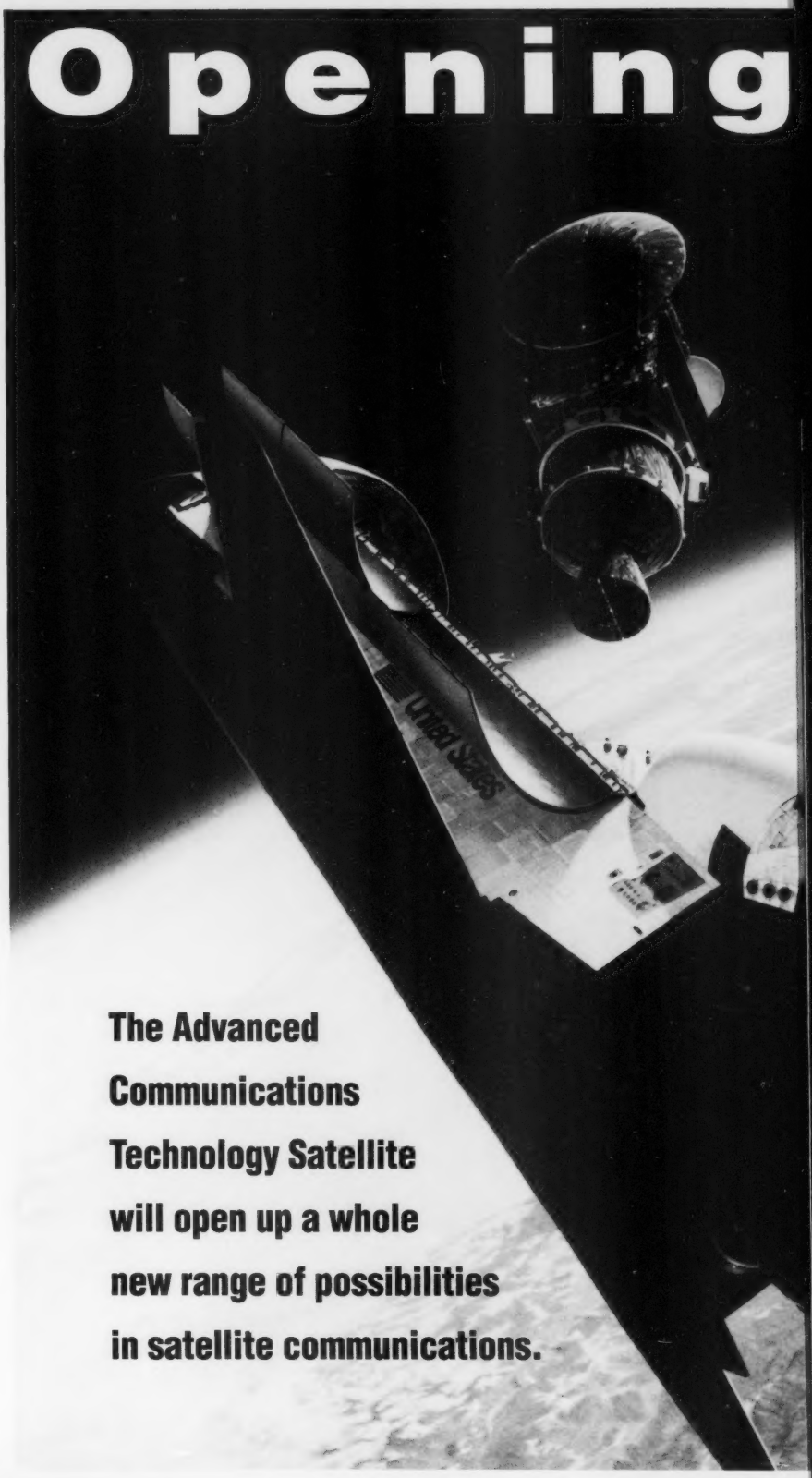
Some 36,000 kilometers above the equator, America's next big business revolution is taking place...every thousandth of a second.

Radio "spot beams" that hop from one location to another in the blink of an eye are sending and receiving video, voice and data transmissions at the speed of light over Ka-band, a frequency never before used in a U.S. commercial communications satellite. Like a telephone switchboard in the sky, the satellite stores, sorts and relays information back to ground antennas only slightly larger than a dinner plate. The dramatic innovation that makes all this possible is NASA's Advanced Communications Technology Satellite (ACTS), which was deployed this fall from Space Shuttle Discovery.

In the early days of the Space Age, the United States, through NASA, took a worldwide lead in orbital communications with an aggressive satellite development program that ultimately set the pace for an emerging telecommunications industry. That pace slackened, however, as the agency dropped space communications from its agenda because of budget considerations and a belief that private industry would push ahead with its own technological innovations.

As it turned out, the private sector, ever watchful of the bottom line, took only hesitant steps in advancing satellite communications.

"Industry is very near-term oriented," explains Richard Gedney, ACTS Project Manager at the Lewis Research Center. "Even though they know technology is important, their real interest is near-term. They have to build satellites on a fixed-price



The Advanced Communications Technology Satellite will open up a whole new range of possibilities in satellite communications.

ACTS

by Michael Giannone

basis and have them work for 10 or 12 years."

Because no single company would take the risk to develop an experimental satellite alone, ACTS was developed jointly. In the late 1970s, Lewis engineers met with industry leaders in an effort to identify future communications markets and determine what technologies had to be developed to satisfy those markets.

Those meetings led to a realization that "maybe NASA had gone too far in cutting back its support of space communications," according to Gedney, and to a renewed commitment by the agency to support space communications research. In the early 1980s, Lewis established the ACTS Project Office to manage the development, assembly and testing of a satellite system that is infinitely more complex than any flying today.

Unlike current satellites that function as "bent pipe" switchers (meaning the signals are sent to the satellite, changed in frequency, and sent immediately back down to Earth), ACTS gives users greater control. ACTS uses an onboard processor that momentarily stores, then routes traffic like a telephone switchboard.

"When you place a telephone call, that call is routed through digital switches throughout the telephone system. On ACTS we basically have an onboard switching system that does the same thing," explains Gedney. "A lot of messages go up to the satellite. The satellite sorts them out and switches them, in essence, to the right destination."

What the satellite actually switches are the hopping, multi-spot

Artist's rendition of Space Shuttle Discovery deploying the Advanced Communications Technology Satellite.

beams. In less than a thousandth of a second, the ACTS beam-forming network electronically hops messages from one location to another. Access to the satellite is on demand. Unlike conventional satellites, where users are billed a flat fee for access, users of an ACTS-type system would pay only for the time they use to send messages.

Ronald Schertler, Branch Chief of the ACTS Experiments Office at Lewis, says that ACTS "opens up a whole new generation of satellite systems, a whole new way of thinking about satellites. Satellites such as ACTS will allow more users to have access to [a greater variety of] services."

From its perch in high geosynchronous orbit, the experimental spacecraft will allow industry to try out these new communications technologies at minimal risk. Business, academia and government agencies use the ACTS system for experimental purposes at no charge, although participating organizations provide their own funding to conduct experiments.

Some 70 experimenters will explore the satellite's capabilities and their own communications needs over a two-year period. The satellite's useful life can be extended to a total of four years if current or future experimenters want to keep using it. Experimenters' access to the satellite will be handled at a master control station at Lewis, which will function as a traffic cop.

The list of experimenters cuts across the full spectrum of communications users, including COMSAT, American Express, the Mayo Clinic, Georgetown University, NASA, the U.S. Army, the Public Broadcasting Service, Southern California Edison, Bellcore, Johns Hopkins University and Motorola.

From high geosynchronous orbit, ACTS will allow industry to try out new communications technologies at minimal risk.

The planned experiments are designed to study ACTS technology and signal propagation as well as potential applications for the satellite. While some investigators test the performance of the in-orbit antenna and collect propagation data, others will transmit high-definition television signals, attempt real-time computer networking and explore the economical delivery of medical services to hospitals and medical clinics.

ACTS represents "a whole new way of thinking about satellites."

Many of these experiments are made possible by the new frequency ACTS is introducing to U.S. satellite communications. This use of the Ka-band (20/30 gigahertz) allows ACTS to handle a variety of communications configurations, from a single voice channel to supercomputers transmitting large data files.

One of the advantages of Ka-band is its very wide bandwidth—five times the bandwidth of current satellites. According to Gedney, that translates to "five times the communications ability of other communications satellites today."

The wide bandwidth coupled with the hopping spot beams means that ACTS is able to concentrate its

signal and transmit information with less distortion and greater reliability.

"The garden variety [satellite] launched today has a very large antenna footprint that covers the whole United States—a 4,800-kilometer diameter. That means all the power is widely distributed," says Rodney Knight, Deputy Project Manager for ACTS Operations and Experiments. "ACTS has an antenna that focuses power into a 240-kilometer diameter. The beam is stronger."

The advanced technology on ACTS will allow communications satellite owners to follow the migration of American business.

"Today we know the major metropolitan areas have high [satellite] traffic demand. We're also finding that cities beyond the major metropolitan areas are attracting businesses, and they, too, want telecommunications services such as satellites," says Schertler. "[The spot beams] allow us to focus the satellite resources on areas where we need the resources. So instead of radiating large parts of the country, we use spot beams and only focus on those areas where there is traffic."

If new regional markets develop, or even if traffic patterns shift over the course of a day, a satellite using ACTS technology could accommodate these market changes, says Schertler.

Concentrated spot beams beaming more powerful signals also mean that Earth stations used to receive ACTS transmissions can be smaller and less complex. An antenna only 30 centimeters in diameter, for example, mounted on a utility pole, will be used by one experimenter to monitor a power grid in southern California.

"The [satellite's] high-gain, high-frequency antenna will allow use of new, smaller stations," explains David Wright, Branch Chief of the Systems Engineering Office. "These smaller ground stations are easy to transport, simple to install, and can handle more traffic than comparable systems today. This means lower costs to the user."

It also means a variety of new services for communications carriers and customers alike. According to Gedney, ACTS technology might even let you catch the big game when you're flying at 30,000 feet.

ACTS Project Manager, Richard Gedney

"ACTS allows you to use very small Earth stations. And we can have a six-inch aperture or station mounted on a commercial airliner," says Gedney. "So one potential new service that might come out of this is real-time TV programming to commercial airlines. You could be flying across the Atlantic on Sunday watching the Pittsburgh Steelers play the Cleveland Browns in real time."

While the opportunity to watch NFL football on the Concorde may still lie in the future, ACTS already has led to innovation, even before its launch. The Motorola Corporation, which built the satellite's onboard switching capability, is currently planning a worldwide communications system using the same kind of processor. The company's proposed Iridium system, a constellation of 66 small-to-medium-sized satellites in low orbit, will offer global personal communications.

"You can be any place on Earth with a handheld radio transmitter, like your remote phone at home, and call any other place in the world," says Gedney of the Iridium concept. "Your signal goes up, then is switched to the appropriate satellite nearby, crosslinked and routed through all these satellites until it gets to the proper place on the globe. Then it goes down and connects you to whomever you're going to talk to."

Another satellite manufacturer is planning a system that will be very similar to ACTS, in that it will use a multi-spot beam, Ka-band system for beaming video directly to small (40 centimeter) antennas in the home.

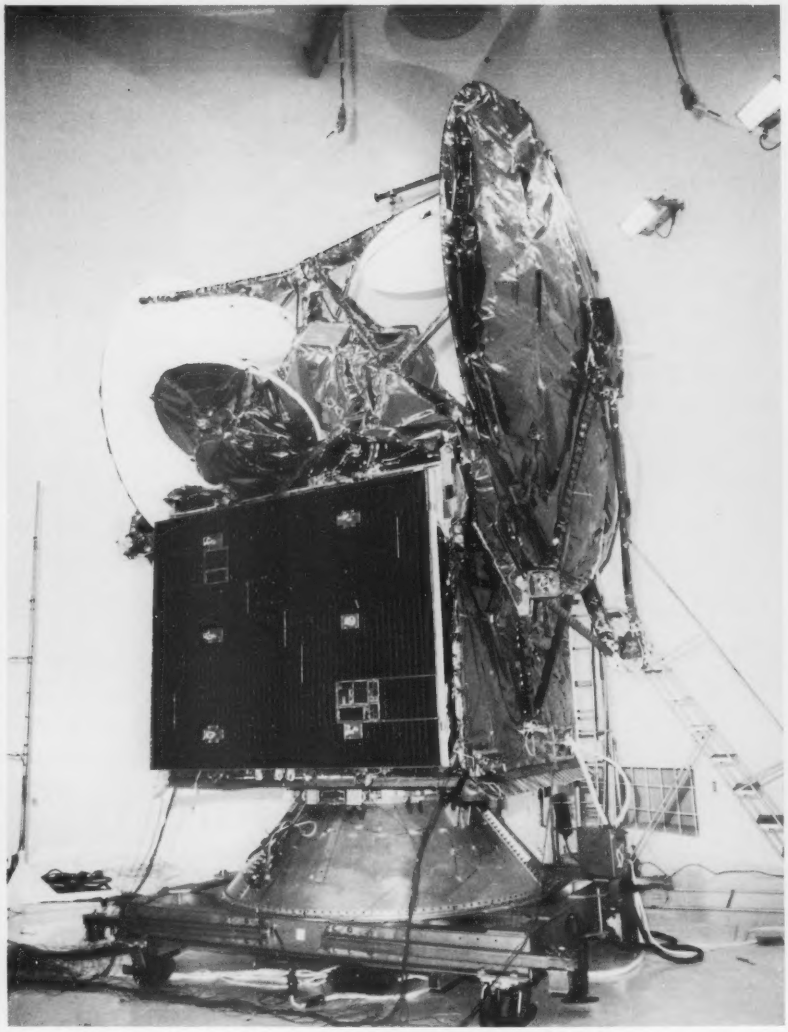
"With this technology, we estimate that costs for communications services on satellites can be lowered by a factor of three for existing [types of] service," says Gedney.

And that doesn't even consider the new types of service that ACTS technology will help introduce to the marketplace.

Once the experimental portion of the program is completed in two to four years, an ACTS-type satellite will probably not fly again, says its builders.

"Iridium isn't ACTS per se, but it's using pieces of ACTS, and that's what ACTS was built for," says Gedney. "We never envisioned people would just duplicate ACTS. It wasn't meant to be an operational system. The concept is that communications carriers would take technology developed on ACTS and incorporate it in their system."

Adds Knight, "I don't think anyone will clone ACTS. ACTS was



It took 14 years for the ACTS satellite to reach the launch pad.

One potential new service would be real-time TV programming to commercial airlines. You could be flying across the Atlantic on Sunday watching the Pittsburgh Steelers play the Cleveland Browns.

not really intended to be the first in a series. We selected a number of new technologies…probably more than someone who wanted to do this commercially would put together on a satellite. So we've got something for a lot of different areas for advancement."

Despite its great promise, it took 14 years for this technological smorgasbord to reach the launch pad. Throughout the 1980s, Congress and the White House were continually at odds over how the ACTS project should proceed.

"The Reagan/Bush administration had a philosophy, not that NASA shouldn't do space communications technology, but that if we do the basic laboratory development, industry ought to be able to go from there. It was a dispute as to how far you take the technology," says Gedney.

With ACTS leading the way, U.S. companies are now showing increased confidence in the technology, which should allow America's commercial satellite communications industry to break through barriers that have kept it at a virtual standstill since the mid-1970s.

"Just like anything, when you break through a barrier, people get confident," says Schertler. "My prediction is that when you look back 20 to 25 years from now, you'll be surprised at how very simplistic and rudimentary ACTS was in comparison to what we'll be flying then." •

Michael Giannone is a writer/editor at the Lewis Research Center. He wrote about educational programs at Lewis in our Spring 1993 issue.

A private company in California is teaming up with NASA's Langley Research Center to turn its invention into something that could benefit the entire U.S. aerospace industry.

X-ray Vision

by Tony Reichhardt

We're all familiar with space program "spinoffs"—technologies originally developed for space suits or planetary probes that later wound up in cardiac pacemakers, or scratchproof eyeglasses, or any one of a zillion other commercial products.

But how about a "spin-*on*?"

Several years ago the Digiray Corporation of San Ramon, California, began looking for ways to improve the standard dental X-ray. Instead of shining X-rays through an object onto a piece of film, the company came up with a device that shoots a narrow X-ray beam through the object, which is then picked up by a small detector. The approach offers several advantages. When an ordinary X-ray passes through a solid material, the radiation is scattered in the same way that light is diffused in a smoky room. Digiray's device eliminates most of the scattering, resulting in much sharper images. The scanner and detector also can fit in hard-to-reach places, like the inside of an aircraft wing.

It was this precision and versatility that caught the eye of Joe Heyman, head of the Nondestructive Evaluation Sciences Branch at NASA's Langley Research Center. Heyman found out about Digiray at a conference, when a colleague showed him images that had been produced by the company's device. From that chance meeting, Langley and Digiray have formed a partnership to help turn the invention into something that could benefit the entire U.S. aerospace industry.

Along with developing software to help analyze the detector's images, Langley is working with the company to increase the energy of the X-ray source so that it can be used for a wider range of applications. Eventually the system could be used to measure very precisely the corrosion on metal aircraft parts, some of which are only a few hundredths of an inch thick. Corrosion and fatigue are unavoidable with mechanical structures. The question is exactly how much corrosion makes an airplane unsafe to fly.

"If we grounded every aircraft that had the tiniest amount of corrosion, we would only be flying planes for a few hours," says Heyman.

But if the corrosion can be measured very precisely, inspectors won't be forced to err quite so much on the side of caution, which means that planes won't have to spend as much unnecessary time on the ground.

"If we were able to absolutely say that there is a level of safety in this aircraft that allows it to be airworthy, then there is no question that would save a tremendous amount of money," says Heyman. "We're talking about typical downtime on an aircraft running into the hundreds of thousands of dollars."

Further in the future, technologies derived from systems like Digiray's could allow engineers to use a device as small as a flashlight to inspect aircraft for otherwise invisible signs of wear and tear. Meanwhile, the company's current system is still finding potential new uses outside the aerospace field. With its tiny scanner and sensor, it might give doctors the X-ray equivalent of a fiber optic probe, which could be inserted in the colon or the esophagus to get stereoscopic X-ray imaging inside the body without surgery.

The partnership between Digiray and Langley—a NASA laboratory helping a private company improve and adapt its invention for wider use in industry—is a model for how government scientists and engineers can work with the private sector, says Heyman.

"I think the reality of the economic situation today is that partnerships are far more important than ownerships," he says. "The critical nature of a national lab is not that it contains all the expertise in the world, but that it acts as a marriage broker, working in a synergistic way with industry and universities to try to bring together teaming and partnerships." •

Science Safari

by Carol Petrachenko

When a group of scientists from the Langley Research Center set out for South Africa last fall to study the effects of biomass burning on the atmosphere, little did they know they would have to be accompanied by sharpshooters with high-powered rifles whenever they left their fenced compound.

Soon after arriving at their research site in Kruger National Park, Langley scientists Joel Levine, Randy Cofer, Eddie Winstead and Dan Sebacher saw a "welcoming committee" of nine lions at a watering hole.

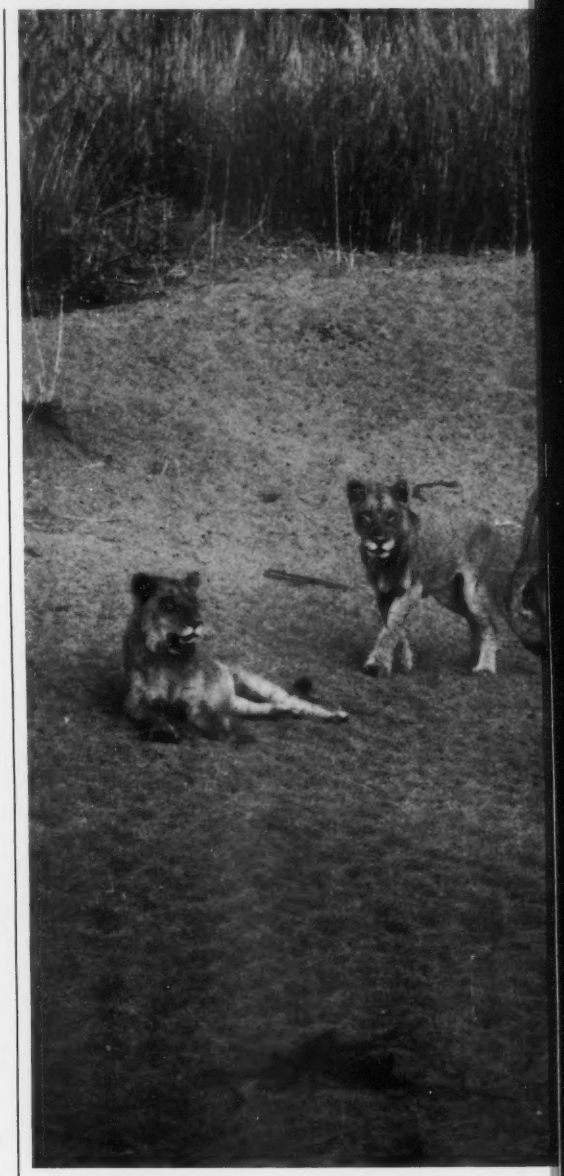
"Our bodyguard assured us the lions were not dangerous," recalls Levine. "He said he could tell by the way they acted that they had just eaten their kill and would not be interested in us."

This was reassuring, says Levine, "especially since we knew lions were not indifferent to human beings." In fact, the remains of several refugees from neighboring Mozambique, who had crossed the border to escape that country's civil war, had recently been found in the wilds of Kruger.

The scientists learned quickly to watch their backs.

"If you wanted to move even 25 feet from the main group," says Levine, "you had to have a bodyguard accompany you."

Kruger National Park, the world's largest wild animal preserve, covers an area of northeastern South Africa roughly the same size as the state of Alabama. The team from Langley's Atmospheric Sciences Division was there to study the environmental effects of savannah grassland fires, which produce as much as a third of the total global emissions from biomass burning. Although grassland fires can result from lightning strikes or human carelessness, most fires in Africa are set deliberately for agricultural reasons. In Kruger, the savannah is burned systematically to make it more available as food for wildlife. Because savannah grass is only tender and nutrient-rich when it is less than half a meter high, park rangers burn the mature, two-meter-tall grass, which begins growing again almost



What are a few lions and mamba snakes to a team of hardy atmospheric researchers?

Above: Lions too full to pounce.

Left to right, Cofer, Sebacher, Winstead, Levine.

immediately.

While Levine stayed on the ground investigating gaseous emissions from microorganisms in the soil (before and after burning), Cofer flew overhead in a South African helicopter specially equipped with a custom nose plate containing data-collecting probes.

"Unlike a boreal forest fire, which can drive a smoke column to 25,000 feet and can smolder for days," says Cofer, "the dry savannah grassland burns so quickly it doesn't destroy the trees it passes through. The smoke column is relatively low, so we flew on the average at about 100 feet."

Staying above the savannah cut down on the number of confrontations with wild animals. But Cofer managed at least one harrowing encounter nonetheless.

The camping areas at Kruger are similar to camps in our national forests, except that they're enclosed by fences as tall as a giraffe. The gates in these fences are closed from 6 p.m. to 6 a.m. to protect the campers inside. Although many wild animals roam the park during the day, even more come out at night, when temperatures drop below the scorching 100-degree daytime highs.

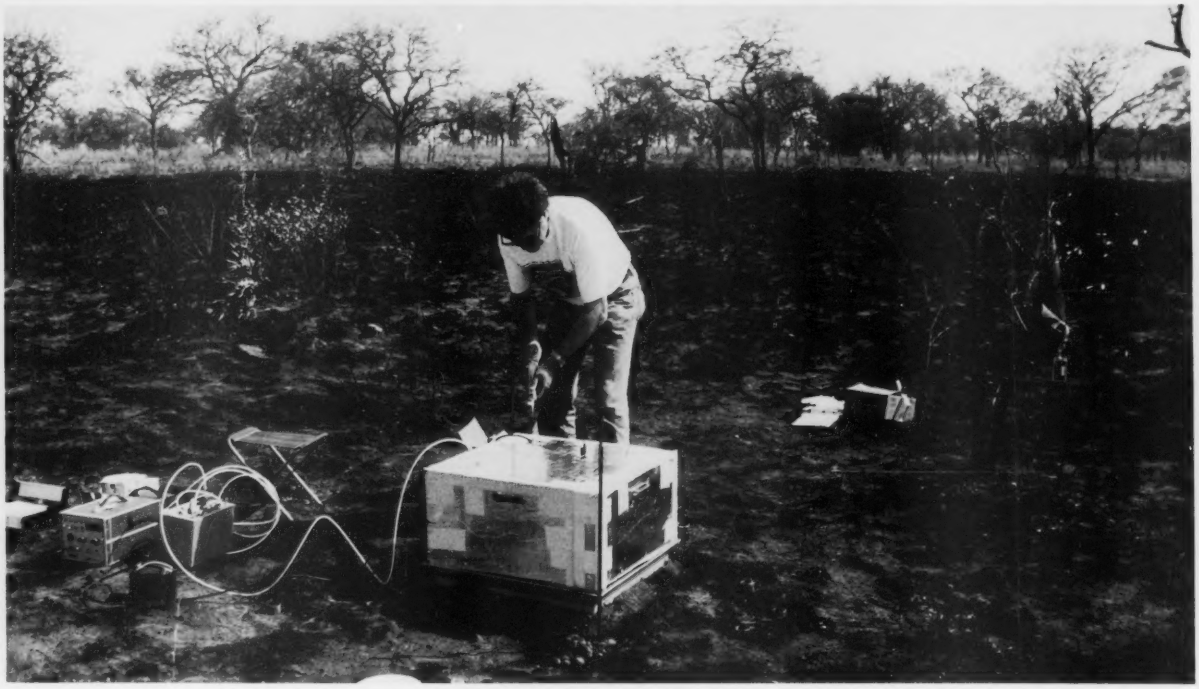
The Langley scientists were warned to steer clear of rhinoceros and hyenas in particular—rhinos because they will charge a car, and hyenas because they're aggressive and relatively unafraid of humans.

"One evening," remembers Cofer, "I got a pass to leave camp after the nightly debriefing to drive the helicopter owner back to a nearby camp about a kilometer away."

Just as Cofer and his passenger reached the locked gate of the other camp, their car was swamped by hyenas.

"It was one of my most terrifying moments," he says. "There were at least a dozen of them. I could see them in my headlights, licking their chops and grinning. They are so ugly with saliva dripping from their fangs! I went into a warp-drive panic!"

Fortunately, blowing the horn and



Levine taking samples after a burn.

blinking the headlights drove the animals off.

But, says Cofer, "We weren't sure just how far into the darkness the hyenas had retreated...or if they might decide to come back. So it was a mad dash to the gate, fumbling with the lock by the light from the car's headlights, my heart pounding."

After the gate clanged shut behind the helicopter owner, Cofer made another "mad dash back to the safety of my car, with hardly a civil farewell."

Daniel Sebacher, a former senior atmospheric research scientist at Langley who now works for Science Application International Corporation (SAIC), has this advice for all researchers in Africa: "In case a herd of elephants happens to cross your path, at least know how to put your rental car into reverse."

On one trip, recalls Sebacher, "A young bull elephant rose 20 feet above my car—his huge trunk and giant front feet extending over the itty-bitty foreign car I was driving. For the life of me, I could not find reverse!"

All ended well when he realized the elephant's display was only a warning to protect the herd.

"If you moved even 25 feet from the main group, you'd have to have a bodyguard accompany you."

The Langley scientists' work in South Africa is part of the Southern Tropical Atlantic Regional Experiment (STARE), an ambitious study sponsored by the International Geosphere Biosphere Program (IGBP)/International Global Atmospheric Chemistry Program (IGAC). More than 200 researchers from 13 countries participated in last year's South African Fire-Atmosphere Research Initiative (SAFARI), which made up half of the STARE experiment. The other half, TRACE-A (Transport and Atmospheric Chemistry near the Equator-Atlantic), gathered similar data in South America. The two sites were chosen in part because they were far removed from sources of industrial or automotive pollution.

"There is more extensive burning globally than we expected," explains Cofer. "Before satellite pictures, we had to depend on the less-than-accurate accounts given to us by various countries—if we could get them. Now that we have satellite pictures, we can get an idea of approximately how

many fires there are in various ecosystems such as boreal, savannah or rain forest."

By correlating satellite figures on the number of fires with data from the STARE experiment, says Cofer, "We can get an idea of the total effect of biomass burning on the Earth's atmosphere."

Emission samples collected in the air and on the ground at Kruger were analyzed on site for greater accuracy. Winstead, a chemist on contract with SAIC, set up a field laboratory for that purpose close to the park's biological lab. It was almost like home, with a few notable exceptions, like the night Winstead was working late and park personnel brought in a two-meter black mamba—one of the world's deadliest snakes—they had just killed in a tree overhanging the park's nursery school playground.

Along with studying the gases produced directly by savannah fires, the Langley team tried to ascertain how the fires affected the production of gases by soil microorganisms. It has long been agricultural practice to burn vegetation so that nutrients, in the form of ash, become more readily available to the soil. When it rains, the ash dissolves into the soil. But eight years ago, Langley researchers discovered that one of the most important of these nutrients—nitrogen—also is *released* from the soil during burns. In fact, on the SAFARI expedition the Langley team found that fires in the African savannah released more nitric oxide than anywhere else they have studied.

For these experiments the researchers used "flux chambers," boxes open at the bottom (where they come in contact with the soil) but closed on all sides so that the build-up of gases can be measured in a precise volume. The researchers can then extrapolate their figures for gas release in a small area to the entire burn site.

The camp where Langley researchers stayed at Kruger National Park.

All this data collection, like everything else at Kruger, presented its own "unusual problems," says Winstead. For example, the scientists would insert half-inch plastic tubes into the ground to take nutrient samples. To keep the samples clean, they covered the tubes with a yellow plastic cap.

"When we'd arrive in the morning to check the tubes, the plastic caps would be missing," says Winstead. "Fortunately, the South African graduate students working with us had the answer. Evidently baboons really like the color yellow. They would raid the sites for the yellow plastic caps. When we changed the color of the caps, the raids ended."

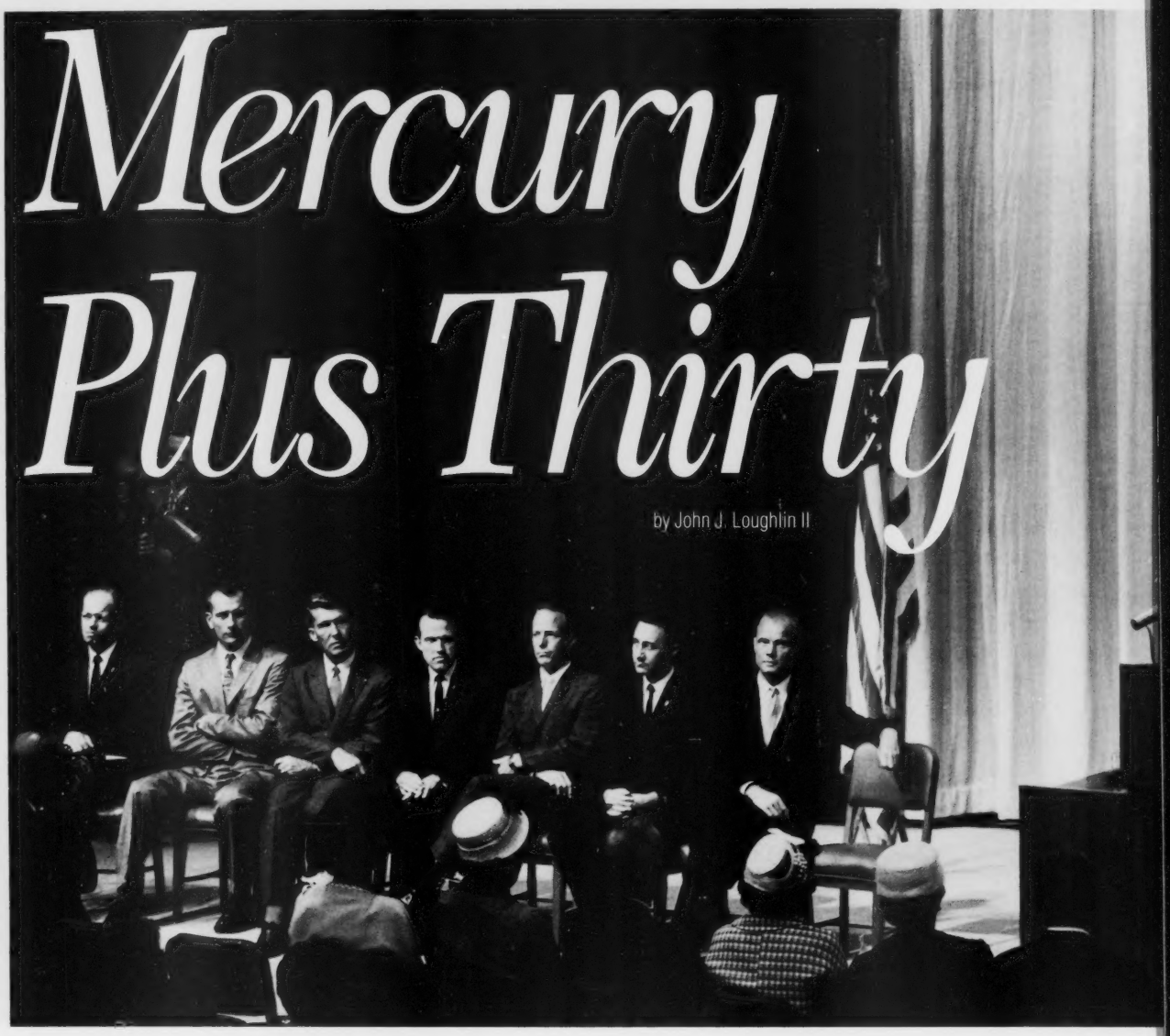
The South African helicopter was fitted with a special nose plate that carries the probe used to monitor emissions from above the fire.

Although working in Kruger was a challenge, it also had its rewards. The evening meal at the camp restaurant featured exotic fruits and vegetables, as well as meats ranging from antelope to impala—the result of controlled hunting to prevent overpopulation among the wild game. While Levine and Cofer favored buffalo steak, Sebacher and Winstead's tastes ran to the more exotic: wart-hog stroganoff. •

Carol Petrachenko is a Bionetics Corporation photojournalist and writer working at the Langley Research Center. Photos by Wesley R. Cofer III, Joel S. Levine, and Edward L. Winstead.

Mercury Plus Thirty

by John J. Loughlin II



They only spent a total of 54 hours in orbit, but America's first astronauts helped to open the Space Age more than 30 years ago.

With the passing of astronaut Deke Slayton in June, America took time to remember not only Deke's own remarkable career in space but also the program that began it all—Project Mercury. Thirty years ago, on May 15, 1963, astronaut Gordon Cooper became the last man to travel into space alone, the last of what author Tom Wolfe called the "single combat warriors."

"Project Mercury really proved we could do it—that we could launch safely, function in orbit and return to Earth," says Cooper, now a Los Angeles businessman.

Fellow Mercury astronaut Walter (Wally) Schirra takes a less reverent view.

"The real point of Mercury," jokes Schirra, "was to prove that we could [follow] the chimp successfully."

Project Mercury consisted of a total of 23 launches, six of which had humans onboard. Before Alan Shepard's first (15-minute) flight in May 1961, surrogate "astronauts" were launched to test the integrity of the spacecraft design, including two rhesus monkeys and Ham the chimpan-

Left, left to right: Shorty "A-OK" Powers with the seven Mercury astronauts, Deke Slayton, Wally Schirra, Gordon Cooper, Scott Carpenter, Gus Grissom, John Glenn and Alan Shepard at podium.

zee. Nine months after Shepard's suborbital hop, John Glenn became the first American to orbit the Earth, fulfilling the project's goal. The six manned flights together added up to only a little more than two days in space.

Mercury was the combined effort of two million government and contract employees, but it was the seven original astronauts who more than anything came to symbolize the American effort in space exploration.

"We became so closely knit, we would almost gang up on anyone who challenged the group," says Schirra.

Alan Shepard is recovered after completing the first suborbital flight of Project Mercury.

A chimpanzee specially trained for the Mercury Redstone 2 flight relaxes with his trainer.

Training for a Mercury flight at the Manned Spacecraft Center—now the Johnson Space Center.

The Mercury astronauts were chosen from a field of 508 test pilots. This list was narrowed by the pilots' own commanding officers to 110 potential candidates, 32 of whom underwent a battery of physical and psychological tests. From this group, 18 were selected to compete for the seven slots as the original Mercury astronauts. Six of the original seven (see page 30) traveled into space inside the one-man Mercury space capsule, which weighed less than a Ford Pinto (approximately 1,360 kilograms).

The spartan vehicle was known for its simple, rugged reliability.

"The Mercury spacecraft was the very last word in advanced technology for its day," says Scott Carpenter, who piloted Mercury Atlas 7 in May 1962. "But by today's standards it's a Model-T."

"The computerized electronics on today's $25 digital watches are more advanced than what we had in the Mercury capsule," says Schirra, now a TV spokesperson.

Schirra recalls the time in 1990 when he was posing in front of his Sigma 7 spacecraft, then on display in Huntsville, preparing to do an advertisement for a cold remedy.

"They had the protective plastic cover removed from the capsule, so just to see what would happen, I reached inside and wound up the onboard computer, which consisted of a mechanical clock tied into the spacecraft systems. I couldn't believe my ears, but it came to life with a tick-tick-tick in perfect working order."

Project Mercury helped lay the groundwork for today's space program and produced several notable firsts, including:

The first American in space—
Alan Shepard (Mercury Redstone 3);
The first American in Earth orbit—
John Glenn (Mercury Atlas 6);
The first live television from space—
Gordon Cooper (Mercury Atlas 9); and
The first satellite deployment from a spacecraft—
Gordon Cooper (Mercury Atlas 9).

President John F. Kennedy congratulates Alan Shepard as the first U.S. man in space.

The Mercury astronauts themselves went on to even more accomplishments. Gus Grissom became the first astronaut to travel into space twice when he piloted the Gemini 3 mission in 1965. Schirra remains the only person ever to fly on a Mercury, Gemini and Apollo spacecraft. And ten years after Shepard became the first American in space he walked on the surface of the Moon, one of only twelve people to do so.

"The real point of Mercury," jokes Schirra, "was to prove that we could [follow] the chimp successfully."

More than just chalking up an impressive list of space "firsts," Project Mercury and the original seven astronauts came to personify America's pioneering spirit and the opening of a new frontier.

Thirty years later, says John Glenn, "Space now is a laboratory, and we go into it to work and learn something new."

According to Scott Carpenter, we may not yet understand the real value of Project Mercury.

"The impact of the dawn of the Space Age, represented by Project Mercury, truly has yet to be realized. It was a great adventure, not just for us, but for the whole country." •

John Loughlin works for Allied Signal and is the senior producer for NASA TV at Headquarters.

The Magnificent Mercury Seven

Alan B. Shepard Jr. (Mercury Redstone 3—"Freedom 7") became the first American in space on May 5, 1961. He walked on the Moon with Edgar Mitchell during the Apollo 14 mission in February 1971. Shepard currently resides in Houston, where he is an independent businessman.

Virgil I. "Gus" Grissom (Mercury Redstone 4—"Liberty Bell 7") nearly drowned and his Mercury spacecraft was lost when the capsule filled with water after the spacecraft hatch blew while Grissom was being recovered from the ocean on July 21, 1961. Although the incident was portrayed in *The Right Stuff* as being controversial, fellow astronaut Gordon Cooper says that the hatch jettison was later duplicated on the ground, and that future Mercury capsules were modified to prevent the hatch from blowing prematurely. Grissom went on to command America's first Gemini flight and became the first American to travel into space twice. He died on January 27, 1967, along with astronauts Edward White and Roger Chaffee, when fire swept their Apollo capsule during tests at the launch pad.

John H. Glenn Jr. (Mercury Atlas 6—"Friendship 7"), the first American to orbit the Earth, captured the public imagination as the darling of the original seven. During Glenn's flight on February 20, 1962, controllers on the ground received telemetry indications that the spacecraft's heat shield may have separated while in orbit. Had this been the case, the capsule would have burned up during reentry. Controllers had Glenn deviate from the flight plan and reenter without jettisoning the spacecraft's retro-pack. The re-entry came off without a hitch. Today Glenn is the senior U.S. Senator from Ohio.

M. Scott Carpenter's Mercury Atlas 7 ("Aurora 7") flight on May 24, 1962, was designed to build upon the success of Glenn's mission. Although the flight went smoothly, some anxious moments came during the re-entry and recovery when Aurora 7 splashed down more than 160 kilometers from the planned point. Today Carpenter lives in Colorado.

Walter M. Schirra Jr. (Mercury Atlas 8—"Sigma 7") spent more than nine hours in orbit on October 3, 1962, adding to engineers' knowledge about the dynamics of longer-duration space flight. Schirra described his journey as "textbook in every way." He later commanded both Gemini 6 and Apollo 7, making him the only astronaut to have flown into space onboard all three early craft. Today Schirra is a retired businessman and CBS TV commentator living in Rancho Santa Fe, California.

L. Gordon Cooper Jr. (Mercury Atlas 9—"Faith 7") Mercury legend has it that Gordon Cooper was pulled at the last minute from this flight and was to be replaced by backup pilot Alan Shepard after he "buzzed" Mercury Operations Manager Walter Williams in his F102 fighter just days before the planned launch. Williams claims that he never really considered removing Cooper from the flight. Either way, Cooper went on to make the last Mercury flight on May 15-16, 1963, then commanded the Gemini 5 mission in 1965. Today he lives in Los Angeles, where he is President and Chief Executive Officer of Galaxy Group, Inc., a company that retrofits airplanes with modern turbine engines.

Donald K. "Deke" Slayton was supposed to have flown into space on the Mercury Atlas 7 mission, but doctors uncovered a slight heart irregularity that grounded him. Slayton remained with NASA as assistant director and then director of flight crew operations. A flight physical in 1970 found that the heart irregularity had corrected itself, and Slayton was reinstated to full flight status. In 1975 he piloted the Apollo Command Module during the historic U.S/Soviet Apollo Soyuz Test Program. He was the last astronaut to pilot the legendary Apollo spacecraft. Slayton died on June 12 of this year at his home in League City, Texas. He was 69.

—John Loughlin

Fear and Fainting in Mountain View

by Jane Hutchison

Volunteers for bedrest studies at the Ames Research Center lie down on the job so that future astronauts will be able to stay on their feet.

It was one o'clock in the morning, still another hour before I could go home. I slouched in a stuffed chair, listening to the ice machine rattle. *Why* had I volunteered for this research project on fainting, anyway?

Whatever the reason, I *had* volunteered. So here I was, sitting in the Human Research Facility at the Ames Research Center, staring at the pages of a magazine. Time to make another circuit of the windowless "bedrest facility" and try to stay awake.

As the Ames public affairs officer for life sciences and advanced life support, I had often worked with the former chief of our life science division, Joan Vernikos, who moved to Headquarters last spring to become director of the Life and Biomedical Sciences and Applications Division. So when I saw an announcement seeking female volunteers for Joan's next study, I decided to check it out. It might make a decent news release, or maybe an article for *NASA Magazine*.

I called a woman who recruits volunteers for human research studies and asked for a copy of the research proposal. Then I mentioned—jokingly—that maybe I should volunteer for this study. I really didn't *intend* to volunteer. It was, after all, a study that possibly involved fainting. Having fainted a few times in my life, even the idea of repeating the experience made me feel lightheaded.

I was told that the purpose of the study was to compare the effectiveness of two methods of expanding plasma volume in the body. A reduced volume of plasma—the fluid part of the blood, without the cells—is believed to contribute to a tendency to feel faint or lightheaded.

Shortly after this conversation, Margie Glazer, a medical programs specialist at Ames, walked into my office. "I understand you're volunteering for Joan's study," she said. "That's great!"

"Well, I haven't exactly volunteered," I replied. "I just mentioned that I might consider it."

It wasn't long before I got an electronic-mail message and a phone message from Joan herself. It was wonderful that I had volunteered for her study, she said. She really needed female volunteers, in particular; she needed six, and only a couple had signed up so far....

I told her I had missed the briefing required of all potential subjects. Not a problem. "We've got the briefing on tape. Just let Dee know when you're available," she said.

"Dee" is Dee O'Hara, manager of the Human Research Facility and a registered nurse with extensive aerospace experience going back to the days of Project Mercury. I read the research proposal. Then I listened to the briefing tape, signed a consent form and scheduled a

From left, Dee O'Hara, Liz Lowe and principal investigator Dr. Joan Vernikos monitor the author's condition during the 15-minute "stand" test. The device on her finger monitors blood pressure.

physical exam. Dee gave me a tour of the facility and explained exactly what would be done to me.

The study had to do with finding ways to counteract one of the peculiar physiological effects of spaceflight. Without the pull of Earth's gravity, astronauts experience an upward shift of body fluids. Faces appear puffy and noses become congested. The body responds to what it perceives as excess fluid by excreting more urine. But when a person returns to the normal gravity of Earth the fluids again shift downward, away from the head, which leaves returning astronauts feeling lightheaded if they stand up immediately after landing.

Researchers have known for a long time that expanded plasma volume may be the solution to this problem. By finding reliable and acceptable means of increasing plasma volume in volunteers, Vernikos believes much of the lightheadedness can be prevented.

"Our purpose is to find the most effective treatment and the minimum effective dose, with the least side effects, for both sexes," she says. "It is very important that we have this information before we test drugs of any kind on astronauts in space."

Space Shuttle astronauts routinely take salt tablets and water just before re-entry. This expands the plasma volume, but the effects have never been measured. People on Earth who experience sudden bouts of low blood pressure and fainting when they stand up are often given Florinef—a synthetic steroid similar to steroids normally found in the body that retain salt and water. For Vernikos' study, each volunteer would be tested under three conditions: after taking salt tablets and water, after taking Florinef, and after no treatment at all. Neither treatment has any side effects, other than possible bloating.

Unlike most previous studies, this one would include women as well as men.

"Women serve as astronauts, but data from flight and groundbased simulation studies are derived almost exclusively from men," Vernikos says. "We need to know if responses to potential treatments vary by sex."

I would make five visits to the Human Research Facility, better known as the bedrest facility. Bedrest in a slightly head-down position, with the "patient" lying

Dee O'Hara injects the dye into the catheter.

tilted at an angle of six degrees, simulates many of the physiological effects of weightlessness. Because responses to treatments may vary not only by sex, but also by time of day, two tests would be run at night. Both the treatments and the time of testing would be assigned randomly to each volunteer.

My first visit started at 7:30 p.m., following a fast that began at noon. I was a control subject this time, so I received no treatment. After weighing in, I had a light breakfast—at 7:30 p.m.!—consisting of half an English muffin with margarine and jelly, a small can of apple juice and a choice of either a cup of water or decaffeinated coffee. Not exactly a banquet, but I wasn't complaining.

Urine collection began at 8 p.m. From then until 2 a.m., urine would be collected every two hours, or more frequently if possible. For the next two hours I was free to read, watch television or listen to music. I explored the facility's hospital-like rooms. There's even a horizontal shower that allows bedrest subjects to wash without standing up. I tried to imagine what it would be like to stay in a windowless room, in bed, with my head tilted down at a six-degree angle for several days or even weeks. It renewed my respect for the volunteers.

I could drink any of the beverages provided—juices, bottled water or caffeine-free soft drinks—as long as I recorded the amount of liquid consumed. At 10 p.m., the testing began. I lay on a bed, passing time by watching television on a set suspended overhead. While medical technician Liz Lowe checked both arms to find the best vein for the catheter, Dee measured and recorded my blood pressure. Hey, this wasn't so bad: lying in bed, snuggled in a blanket, watching television. People kept asking if I was comfortable. I could get used to this!

After a few minutes, Liz inserted the catheter needle into my arm. The butterfly catheter is a great invention. It allowed Liz to take blood samples and Dee to inject dye without requiring a separate needle stick for each procedure. An intravenous drip of glucose solution kept the line open.

At 10:25, Liz drew a pre-test blood sample. I glanced at my arm and noticed it was covered with a maze of tubes, tape and bandages. Dee then injected a blue dye into the catheter. This would be used to measure any changes in plasma volume. Liz drew a second blood

sample 10 minutes later. Then it was time to stand up.

Standing, it turns out, was a choreographed group effort. First I swung my legs over the side of the bed, keeping my upper body flat on the bed. Joan stood behind me, supporting my back. Liz supported my arm, and Dee guided my legs. I slid off the bed onto a wooden box that served as a step. It's a long drop to the floor, especially for a short person like me.

"Look straight ahead, and don't move anything but your eyes for the next 15 minutes," Dee said. A soft pad provided some support for my catheterized right arm. A pressure cuff on the first finger of my left hand relayed my blood pressure and pulse rate to a nearby machine.

Holding my left hand against my chest at heart level, I stood on the box, chatting with the people monitoring my condition. Except for feeling as though the pressure cuff were turning my finger blue, I felt fine.

Dee stood in front of me, counting off the time until the next blood draw. Joan watched the readout on the machine. Liz stood ready to draw blood samples five and 15 minutes after the test started. But I never got that far.

After about eight minutes, I started feeling a little queasy. "It's OK, it's probably just nerves," I thought. A few seconds later, I realized the feeling wasn't going to pass. "I don't feel so great," I said. Immediately the testing stopped, and I was helped onto the bed.

"Perfect! That's just what we wanted," Joan said. She was pleased that I had told her as soon as I had begun to feel faint, rather than trying to hold on a little longer. It was important to know at what point lightheadedness started. Dee noted that she had seen the "strange" look on my face before I spoke up. I was fine, though, as soon as I was horizontal again.

It was now about 11 p.m., and there were still three hours to go before I could leave. By now the night nurse had arrived. We had dinner—salad, lasagna and a roll—just before midnight. Then I was free to kill time as long as I stayed awake and continued to collect my urine at two-hour intervals.

Being the night owl I am, staying awake wasn't a big problem for me…at least until 1 a.m. or so. I read and listened to my CD player; unfortunately, the soft jazz didn't help me stay awake. I checked my watch about every five minutes. Finally, it was time for the last urine collection. At 2:03 in the morning, I headed for home.

A month later, I was back in the Human Research Facility for another round of testing. The drill was the same as before, with no medication, but this time I made it through the entire 15-minute standing session on my feet. Unlike non-NASA subjects, who have to stay in the bedrest facility for six hours after the test starts, I went back to my office. That meant, however, that whenever I felt the urge to urinate I had to make sure I left enough time to get back to the bedrest facility—two to three blocks away!

The worst part of this test was the rule about no caffeine until the testing was over at about 2 p.m. I really missed my morning hit of caffeine, and I had a crashing headache all day. Not being able to take aspirin only added to my irritability. My poor office mate confided later that I was "rather cranky" that day.

The third test was another night session. This time I was given a treatment. I took two Florinef tablets at 8 p.m. the day before, at 8 a.m. and again at 8 p.m. the day of the test. I had a slight headache that morning, but none of the bloating I had expected.

I went into this session somewhat apprehensive. I was very tired and felt I wouldn't last too long. I was right. But interestingly, I didn't have any trouble staying awake. Maybe it was because there was another woman being tested, too—someone new to talk to.

After a fourth test (again with Florinef) the following month, I had only one more round to go. The salt tablet and water treatment that concluded my stint as a volunteer is something I hope never to repeat. Four eight-ounce glasses of water and eight salt tablets in 20 minutes left me feeling like the Goodyear blimp.

Several people have asked why I volunteered for this study, especially when they hear about the needles and the fainting. Two reasons come to mind. First, I've always had an interest in biology and medicine. I appreciated the opportunity to be actively involved in life science research, rather than just writing about it.

It also was a chance to add to a very small database of information about how women adapt to space flight. I don't know whether my responses were typical or whether they helped answer any important questions. But maybe I've helped to make space travel safer and more enjoyable for future female space explorers. •

Jane Hutchison is a Public Affairs Officer at NASA's Ames Research Center.

Langley

NASA, Meet KASA

They looked like ordinary students. But when a group of children from the Carpenter Elementary School in Wolfeboro, New Hampshire, descended on the Langley Research Center this summer, they instantly metamorphosed into "AstroKids." The students, aged nine through 13, created the Kids Aerospace Simulation Activities (KASA), which consisted of a "space plane," a half-size school bus- *cum* mission control, and computer and video simulations. During their "mission" at Langley, the students departed a Mars base in search of a solar flare.

Photo/courtesy Fred Jones, LaRC

AstroKids Laura Maxfield (left) and Hannah Fallon designed and constructed a complete human colony on the Red Planet.

Carpenter teacher Irene Ladd came up with the idea for KASA after attending the NASA Educational Workshop for Elementary School Teachers (NEWEST) at Langley. For their traveling show, the students videotaped scale models and used computers to animate the images that appeared in the space plane during their mission. They combined these images with NASA film clips and transferred them onto a laser disk that runs the simulation.

In the future, Ladd and the AstroKids hope to expand KASA's appeal by keeping the show on the road. •

Lewis

Opportunities Knock

Last spring the Lewis Research Center, in cooperation with several federal, community and university organizations, sponsored a two-day conference aimed at encouraging Cleveland's handicapped high school students, particularly minorities, to consider careers in aerospace. The series of workshops on "Mainstream America: Partnerships and Linkages for Success" was structured to provide participants with a well-rounded introduction to NASA and the aerospace community.

"We wanted to reach the students and make them aware of their opportunities in aerospace technologies—specifically NASA student programs—that could enhance their career choices," says William Nyerges, the program manager for Lewis's Office of Educational Programs.

The 150 students, parents and educators who attended the conference encouraged Lewis to make it an annual event. •

Kennedy

Young and Ambitious

A 16-year-old student journalist and self-professed space buff from Carrollton, Ohio, was very impressed to get an interview with Kennedy Space Center Director Bob Crippen after the launch of the STS-57 Space Shuttle mission in June. Justin Ray, whose hometown is in farm country, says that local news media do not fully explain the importance of the space program, concentrating instead on negative stories. The high school junior wants to study journalism at a Florida college, then get a job with Public Affairs at Kennedy, where he could help change the situation.

During his interview with Crippen, Ray asked the four-time Shuttle astronaut for his assessment of the importance of space exploration.

"Space exploration is important to America, and what's important for America is important to the farmer, to labor, to bankers, to everyone," Crippen said.

Ray headed back to Ohio to deliver that message. •

JPL

Crystal Clear

Virgil Shields, a doctoral student in Howard University's Materials Science Research Center of Excellence in Washington, D.C., recently made an important advance in research to develop new materials that will allow semiconductors and electro-optic circuitry to work faster and more efficiently in extreme temperature and radiation environments, such as those encountered by spacecraft. Under a fellowship at the Jet Propulsion Laboratory, Shields came up with an innovative process for producing high-quality monocrystalline beta-silicon carbide at very high bulk growth rates. The process would also benefit sensors and electronics on jet engines or automobile engines. According to Shields, before his experiment, high-quality crystals had never been consistently grown in bulk amounts.

"We have demonstrated a 300 percent improvement in quality so far…producing 100 microns per hour of this material," he says.

The JPL Minority Fellowship Program enables JPL employees from under-represented minorities to pursue graduate degrees while remaining on the Laboratory staff. •

Goddard-Wallops

The P-3A Orion flew 3,000 hours at Wallops, bringing its lifetime total to 10,469 flight hours.

Worldwide Traveler Retires

NASA's venerable P-3A Orion retired in June after 28 years of loyal service. The aircraft left the Wallops Flight Facility, where it had been since September 1977, to return to the U.S. Navy at Moffett Field, Calif., where it will be placed on display. In its 16 years at Wallops, the four-engine turboprop plane flew in four continents and traveled from the North Pole to the southern tip of Chile. The Orion's missions took it to Canada, Greenland, Ireland, Sweden, Norway, Spain, Gambia, Morocco and Peru. A major use of the aircraft, in addition to its launch range surveillance duties at Wallops, was to assist researchers in studying the oceans. The P-3A also carried instruments to study emissions from three different volcanic eruptions. Before coming to Wallops, the aircraft flew 725 hours while it was still being developed at Lockheed, then went on to the Navy and to NASA's Johnson Space Center. •

Johnson

On Target

When a Soyuz capsule undocked from its port on the Russian Mir space station last June, the cosmonauts inside were looking at a Johnson-built "target," a piece of hardware that could be crucial to the success of a future Space Shuttle-Mir docking mission. Under an agreement made in 1992, NASA is planning to rendezvous a Shuttle with Mir on STS-63 next June and a docking mission on STS-71 in June 1995. Alignment of the docking mechanisms is critical, and the targets that were on the Mir didn't fit the bill. The Russians agreed that a new target was a requirement, but they said they needed the target in hand by the middle of March to meet the next scheduled launch of a Progress supply ship.

The Shuttle program staff decided to step up to the quick-turnaround timeline and go for it. Based on a single diagram of the hatch where the target would be placed and numerous international faxes and telephone calls, the Johnson team set to work on what turned out to be a four-week hardware production schedule–and all of this accomplished with Johnson management looking closely over the team's shoulders throughout the entire process. Despite a snafu with the shipping of the target, it nonetheless was placed on the last-chance Progress supply vehicle that launched last May and was installed successfully in June. Greg Lange, the project engineer in the Shuttle Cargo Engineering Office says, "This is the first hardware we shipped to the Russians for these cooperative missions, and you sure don't want to have a bad product going over there. We gave them something NASA could really be proud of, made sure it fit the first time." •

Stennis

Flying Over the Flood

At the request of the Federal Emergency Management Agency (FEMA), researchers from the Stennis Space Center flew specialized airplane-mounted sensors over parts of the flooded Midwest last summer. Digital imagery of the area was collected, analyzed by computer and compiled more quickly than conventional photographs could be, to provide immediate information about changing conditions. FEMA is using the NASA images to assist in charting flood-damaged areas, to improve its computer database on the region and to update flood insurance maps. The data also will be used to assess the status of residential and industrial areas as well as infrastructure such as roads, bridges and rail services.

Stennis Director Roy Estess says, "The NASA data will be especially useful to FEMA in their efforts to quickly settle flood insurance claims, making sure those who need the help receive assistance in a very timely manner." •

An Englishman writes in praise of NASA and its embodiment of "the highest of human qualities." How many government agencies, he asks, can claim to have achieved legendary status?

Three Cheers for NASA

by Richard Mott

A friend of mine who works for NASA sends me *NASA Magazine* from time to time. I thought I would write to you on the (off) chance that you may be interested to learn of the impact NASA and the Space Age have had on one ordinary Englishman.

I am 42 years old and have been to the United States six times. In four dedicated trips [during the 1970s] I managed to visit every NASA Center at least once. In 1980 I was able to go to the Dryden Flight Research Facility, a glorious day that proved to be the crowning achievement of my long-sought ambition. Earlier in that trip I met briefly with former [NASA Administrator] Dr. Robert Frosch and Congressman Don Fuqua, and spent some time with former astronaut Scott Carpenter in Los Angeles.

I am not connected with the aerospace industry, nor have I ever been. I cannot remember a time when space did not fascinate me. To have been alive when the Space Age dawned and to be able to witness it as it progresses is a great privilege. And it seems wholly natural that America should be best and number one in this field.

The people who ask, "Why spend money going into space?" may as well ask *why*, period. With death the only certain outcome of being alive, it could be argued that there is no point in doing anything. But we do, and we must continue doing.

All my trips [to America] were planned and financed by me alone. My interest in NASA is not mindless idolatry, but a logical, steady reverence for an organization charged with the mission of taking humankind ever upward in achievement and aspiration. If the desire to do this ever fades, not only will it signal the gradual decline of a great nation, it will be symptomatic of a people who have defeated one enemy—the threat from the East—only to succumb to an invisible and far more dangerous adversary—apathy. When we stop caring, we stop doing. And when that happens, we start dying.

Although NASA is American, it expresses the highest of human qualities. I am not blind to the problems and imperfections that any human endeavor is bound to suffer, and from which none is exempt. But how many government agencies around the world can rightly claim to have attained legendary status? Just one.

I am concerned about the world into which my eight-month-old daughter is growing up. Will it be one of hope or despair? The Western world seems to be going through a period of self-doubt and loss of direction. We can only hope it is temporary.

In closing, I remind you that I am not a U.S. taxpayer— the Queen won't let me give my taxes to NASA! Long live the Space Program.
Long live NASA.

Yours most sincerely,
Richard Mott

Richard Mott wrote to NASA Magazine *from his home in Stafford, England.*

LAUNCHES

• STS-61—Endeavour and its crew set off on the Hubble Space Telescope repair mission, one of the most important Shuttle missions to date.

• STS-60—Space Shuttle Discovery will carry Spacehab-2 and the Wake Shield Facility-1 on this scheduled 8-day mission.

EVENTS

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OCTOBER
Happy 35th Anniversary, NASA.

7
DECEMBER
The Technology 2003 Conference opens in Anaheim, CA, through Dec. 9.

NASA
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Administration